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GRAVITY GRADIENT BOOM STABILIZATION SYSTEM
for the
APPLICATIONS TECHNOLOGY SATELLITE (ATS-E)

Final Report Vol II
Contract No. NAS 5-10285

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Prepared for
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Greenbelt, Maryland

by

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THE ATS GRAVITY-GRADIENT BOOM

QUALIFICATION TEST REPORT

NOVEMBER 1969

AEROSPACE TEST LABORATORY
WESTINGHOUSE DEFENCE AND SPACE CENTER
AEROSPACE DIVISION
BALTIMORE, MARYLAND

CONTRACT NO. NAS-5-10285
DOCUMENT NO. ATL-338

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A B S T R A C T

The Aerospace Test Laboratory of the Westinghouse Aerospace Division conducted the Environmental Design Qualification Test on the Gravity-Gradient Boom System, a part of the Applications Technology Satellite (ATS-E), for the National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC) under contract NAS-5-10285.

The following tests were conducted on the Prototype Unit serial number 0001 according to the Aerospace Test Laboratory Document ATL-0246:

Vibration

Acceleration

Thermal-Vacuum

During this test program electrical and mechanical functional tests were performed, as specified in ATL-0246. The deviations from this procedure, ATL-0246, are noted within this document.

This report includes a detailed summary outlining environmental exposures, facilities and instrumentation used, procedures employed, test data and the results of the Environmental Qualification Testing.

1.0 ADMINISTRATIVE DATA

1.1 Purpose of Test

The purpose of the Environmental Design Qualification Tests was to demonstrate the ability of the ATS-E Gravity-Gradient Boom System to meet the design performance requirements described in Westinghouse documents T789493 - Qualification Test Procedure for A.T.S. Boom/Deployer System, and ATL-0246 - Environmental Design Qualification and Acceptance Test Specification for the Gravity-Gradient Boom Half System.

1.2 Identification of Unit Tested

The Gravity-Gradient Boom System (hereafter referred to as the G/G Boom System) is part of the Applications Technology Satellite-E. The Prototype tested was unit serial number (S/N) 0001.

1.3 Test Dates

Test	Start	Completed
Vibration *	12-10-68	2- 1-69
Acceleration	2- 4-69	2- 4-69
Thermal-Vacuum	2- 7-69	2-22-69
Special Harmonic Drive Testing	5-19-69	5-29-69

* NOTE: Various Engineering tests were performed on the tip mass assembly during the vibration testing.

1.4 Test Conducted By

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1.5 Security Classification of Test Items

TEST ITEM	SECURITY CLASSIFICATION
G/G Boom Half System	Unclassified
Test Equipment	Unclassified

1.6 Reference Documents

A. NASA

Document No. S2-0102 Environmental Qualification and Acceptance Test Specification (Component Testing)

Document No. S-460-P-1 Specification for A Gravity-Gradient Boom System for Project ATS

B. Westinghouse

Drawing 662R808 ATS Boom System

Drawing 662R809 G/G Boom Outline Drawing

Document ATL0246 Environmental Design Qualification & Acceptance Test Specification for the Gravity-Gradient Boom System

Document T789493 Qualification Test Procedure for ATS Boom/Deployer System

Document T853589 Test Procedure for the Gravity-Gradient Boom Special Prototype Testing

Document ATL339 The Gravity-Gradient Flight Acceptance Test Report

1.7 Summary

The G/G Boom System was subjected to the prescribed vibration, acceleration, thermal-vacuum and functional testing of the Westinghouse test specification ATL-0246. The system satisfactorily completed the vibration and acceleration qualification test program, but the G/G Boom Qualification Unit never completed the design qualification thermal-vacuum functional testing in the manner prescribed by the test specification T789493 (see section 3.3.3). The results of the thermal-vacuum functional testing indicated that further testing was required on the harmonic drive system of the unit. A joint decision was made by Westinghouse and GSFC/NASA at the conclusion of the formal qualification testing of the prototype unit, that a "Special Harmonic Drive Test," while in a thermal-vacuum environment, would be performed on the qualification unit. This test was performed in order to develop sufficient confidence in the harmonic drive system.

The results of the "Special Harmonic Drive Test" (see Appendix III) were presented to the customer (NASA/GSFC). Consequently, the Launch Readiness Review Board of NASA/GSFC approved installing on the ATS-E spacecraft the G/G Boom flight units waivering the "out-of-spec" functional Test Data of the previously completed flight acceptance test program. Thus, based on the acceptance of the flight units, the results of the Special Harmonic Drive Test and vibrational design modifications of the unit, the ATS Gravity-Gradient Boom System was considered to have satisfactorily met the modified design performance requirements of Westinghouse documents T789493 and ATL 0246.

2.0 TEST PROCEDURE

2.1 Test Sequence

The Environmental Design Qualification Testing was conducted per a modified version of the Westinghouse Aerospace Test Laboratory Document ATL 0246. The modifications of that document are noted accordingly in this report. The G/G Boom System was subjected to the following sequence of tests.

1. Previbration Functional Test
2. Vibration Test
3. Postvibration and Preacceleration Functional Test
4. Acceleration Test
5. Postacceleration and Prethermal - Vacuum Functional Test

6. Thermal-Vacuum Test

7. Postthermal-Vacuum Functional Test

8. Special Harmonic Drive Testing (see Appendix III)

The Time History and Environmental Exposures to which the G/G Boom Prototype Unit S/N 0001 was exposed are shown in figures 2-1 and 2-2.

2.2 Description of Tests

2.2.1 Vibration Testing

2.2.1.1 Vibration Test Equipment

Vibration Exciters	MB C-210, MB C-220, and Calidyne 177
Accelerometers	Endevco Models 2242 and 2222A
Amplifiers	Endevco Model 2705
Tape Recorder	Ampex FR 100A

2.2.1.2 General Description of Vibration Testing

The vibration testing was performed in accordance with Westinghouse test specification ATL 0246. However, the following deviations occured during this phase of testing.

The first deviation from ATL 0246 resulted from a change in the sinusoidal vibration levels during the qualification test program. This revision came as a result of a NASA/GSFC directive to Westinghouse. The new levels specified are indicated in Table 2.2-1 and are the levels to which the G/G Boom System was qualified for the sinusoidal vibration. Also, in deviation to the vibration test procedure of ATL 0246, the G/G Boom System was subjected to a 2g sweep from 10 to 2000 Hz prior to the qualification levels. This 2g sweep was instituted throughout the sinusoidal vibration. The random vibration was performed in accordance with the procedures of the Westinghouse test specification

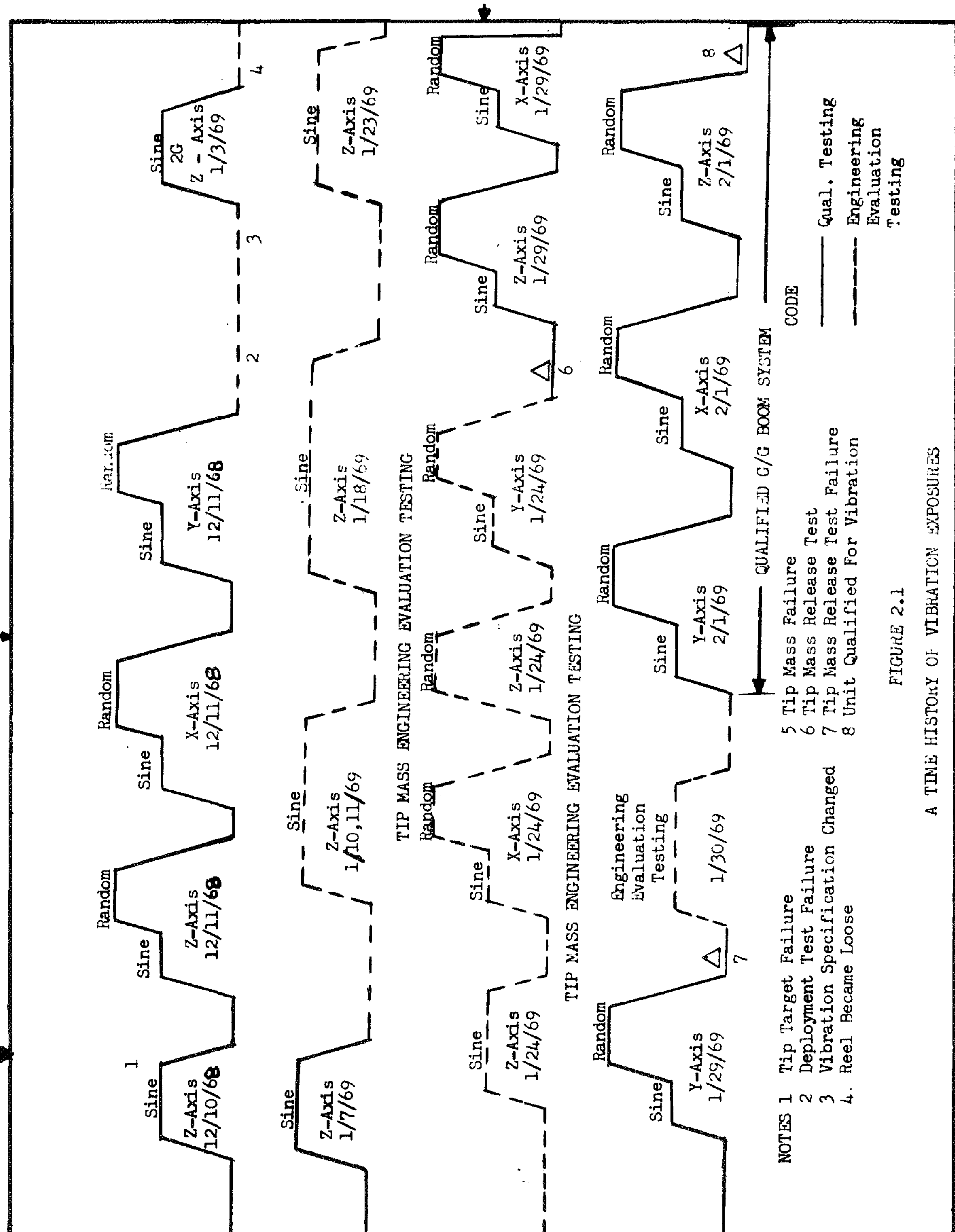
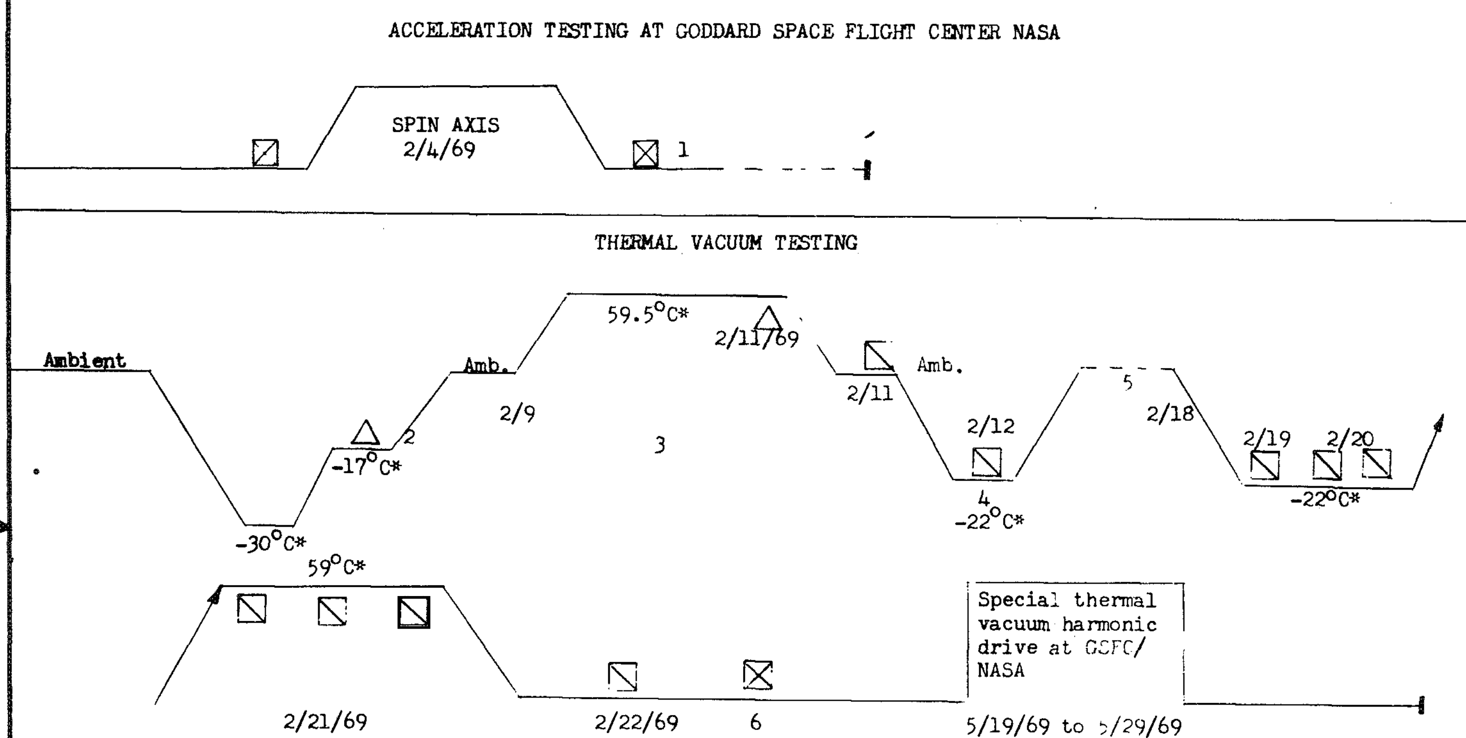


FIGURE 2.1

A TIME HISTORY OF VIBRATION EXPOSURES



NOTES:
1 Postacceleration functional testing
2 Squib firing problems
3 Lost pressure for ten minutes on 2/10/69 **maximum pressure** in chamber 9 x 10^{-5} torr
4 Scissoring failure
5 Reworking the unit
6 Functional testing at Magothy Manor

ABBREVIATIONS USED:

△ = TMR = Tip mass release test

= Limited extension/retraction scissoring tests

= Full performance test

* = Indicates that the pressure is less than 1.0 x 10^{-5} torr at the specified thermal conditions

FIGURE 2.2 A Time History of Acceleration and Thermal-Vacuum Exposures

TABLE 2.2-1

SINUSOIDAL VIBRATION LEVELS FOR THE

G/G BOOM DESIGN QUALIFICATION

AXIS	FREQUENCY (CPS)	LEVEL (PEAK G)
LATERAL X-X and Y-Y	5 - 9.5	0.45 inches DA
	9.5 - 20	2.0
	20 - 120	9.0
	120 - 200	2.0
	200 - 2000	5.0
THRUST Z-Z	5 - 8	0.9 inches DA*
	8 - 25	2.5
	25 - 45	12.5
	45 - 60	25.0
	60 - 80	8.0
	80 - 200	3.0
	200 - 2000	5.0

(Vibration Sweep Rate: 2 Octaves/Minute)

* Use Max. Shaker Displacement

ATL-0246 throughout the qualification test program. Figure 2-3 shows the unit with its test fixture mounted in the Thrust (Z-Z) Axis configuration.

2.2.2 Acceleration Testing

2.2.2.1 Acceleration Test Equipment

Genisco Centrifuge Model 1230-1G-Accelerator

(NOTE: This test was performed at GSFC/NASA)

2.2.2.2 General Description

The acceleration test was conducted per the Westinghouse specification ATL 0246 at a NASA supplied test facility at the Goddard Space Flight Center in Greenbelt, Md. The unit was subjected to a 23g force in the prescribed axis for 3 minutes. The G/G Boom System was then subjected to a Postacceleration Functional Test, as defined in Westinghouse test specification T789493. Also, in addition to the required postacceleration performance tests, the unit was subjected to a tip-mass release test.

2.2.3 Thermal-Vacuum Testing

2.2.3.1 Thermal-Vacuum Test Equipment

Bristol Temperature Recorder S/N 63A15,961

Veeco Vacuum Gauge Amplifier S/N 31472

Veeco Vacuum Gauge Type RG-3A

Bethlehem Corporation Thermal-Vacuum Chamber (#4) LA 0461

2.2.3.2 General Description of Thermal-Vacuum Testing

The G/G Boom System was subjected to the required thermal-vacuum testing as specified in Westinghouse document ATL 0246. The environmental tests were performed within the specified environmental limits and tolerances and in the required sequence.

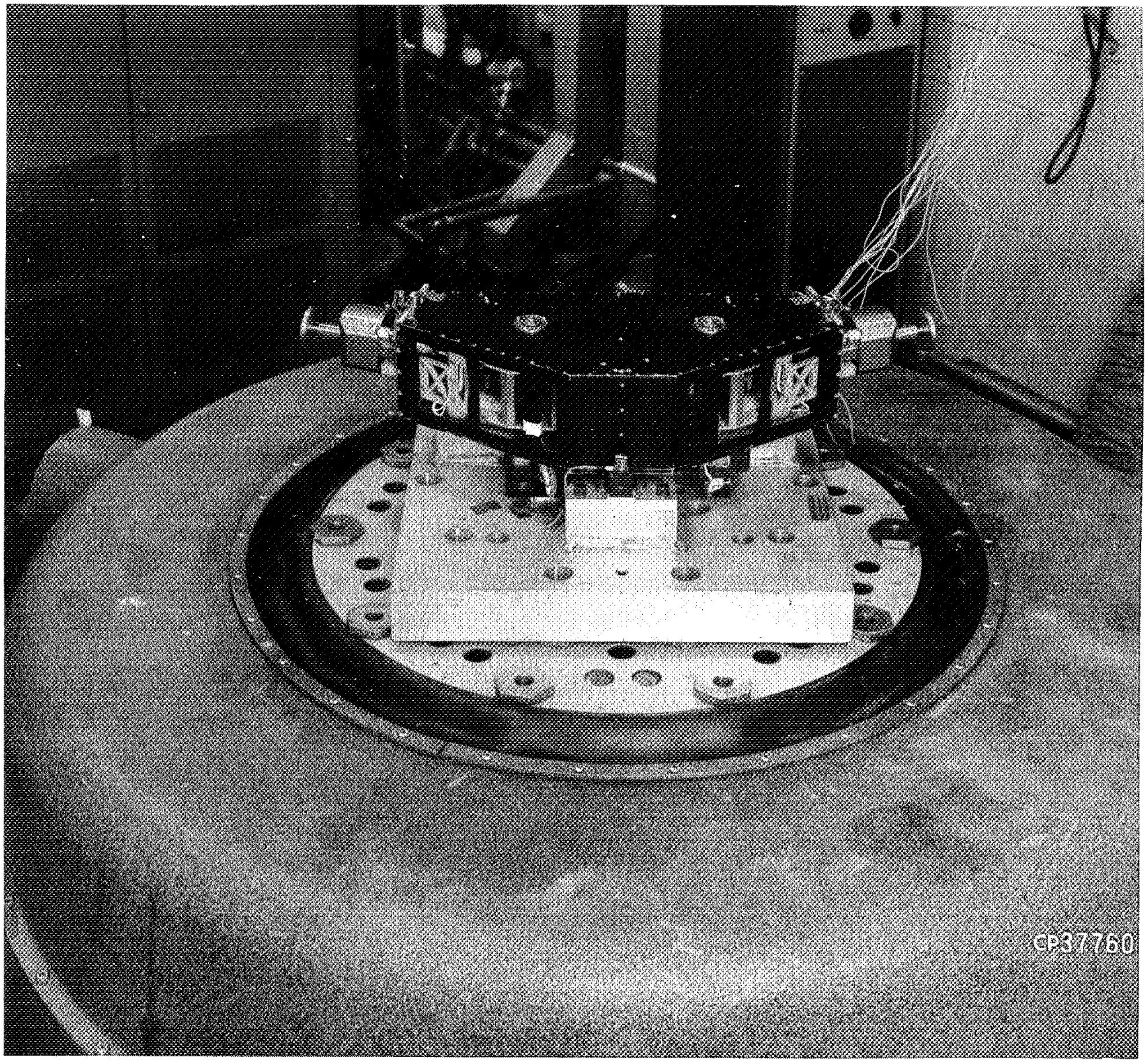


FIGURE 2-3
G/G BOOM SYSTEM MOUNTED ON THE VIBRATION TEST FIXTURE
(Z-Z AXIS, THRUST)

As a result of the failures that occurred in the harmonic drive system during prequalification and qualification testing, additional tests on the harmonic drive system were required for obtaining the necessary confidence in the unit's harmonic drive system. This Special Harmonic Drive Test was performed by Westinghouse personnel at a NASA/GSFC supplied facility in Greenbelt, Md. This test is described in the test procedure which is included in Appendix III of this report.

2.2.4 Functional Testing

The functional testing is described in detail in Westinghouse document T789493, which is shown in Appendix II of this report.

(NOTE: Hereafter the extension/retraction and scissoring testing will be refered to as E/R & S testing and the tip-mass-release testing will be refered to as T-M-R testing.)

3.0 TEST RESULTS

3.1 Vibration Testing

3.1.1 Resulting Design Modifications

As a result of vibration testing, several design modifications were incorporated in the G/G Boom System design. These modifications resulted from failures and discrepancies during vibration testing at qualification levels. The discrepancy, analysis, and corrective action for each instance is presented in chart form in Table 3.4-1 of this report. The items that resulted from the vibration testing are Items 1 through 5 (inclusive).

3.1.2 Vibration Data

Throughout the vibration testing, data was recorded on magnetic tape and reduced to X-Y plots of frequency vs. acceleration. Due to the numerous vibration tests, considerable amounts of data were acquired during the test program. However, this report will present only the input and response plots from the final qualification level tests since this data was acquired during the unit's final configuration. The input and response plots can be found in Appendix I. Also the data from selected main structure points is summarized in Table 3.1-1, and accelerometer positions clarified in Figures 3-1, 3-2, 3-3. It should be noted that the vibration sweep in the thrust (Z-Z) axis was not continuous (as is evident from the data). This was due to a decision to check the unit between each change in vibration level in order to find, as soon as possible, any discrepancies that occurred during the vibration testing. This procedure was acceptable to the NASA/GSFC Technical Officer present during the testing.

3.1.2.1 Z Axis (Thrust Axis)

The major structural areas monitored during the Z-Z Axis vibration were: the slave tip mass, the base of the scissor mechanism, which corresponds closely to the unit's center of mass in the Z-Z Axis, and each of the deployers' scissor pivot shafts, which correspond to their centers of mass. The major resonances and the corresponding transmissibilities are contained in Table 3.1-1 with the accelerometer locations in Figure 3-1. As can be seen in Table 3.1-1, no major resonances occurred at less than 160 cps. It should be noted that a fundamental resonance appeared at 160-162 cps. on the main structures of the unit (those listed in the Table 3.1-1, Z-Z Axis). Other resonances appeared between 182 and 650 cps during this test. The major tip mass resonance appeared at 212 cps with a transmissability of 3.5.

3.1.2.2 X & Y Axis

Due to the unit's configuration and basic shape (see Figure 3-2), accelerometers could not be easily mounted directly on-axis for either the X-X or the

TABLE 3.1-1

VIBRATION DATA ANALYSIS

AXIS OF VIBRATION	FREQ. CPS	INPUT (G's)	RESPONSE (G's)	ACCEL. #	TRANSMISS. (Response / Input)	LOCATION
Z-Z	160	3.0	5.6	1-Z	1.8	Base of Scissor Box (In Axis)
	182	3.0	7.5	1-Z	2.5	
	212	5.0	12.0	1-Z	2.4	
	610	4.6	16.0	1-Z	3.5	
Z-Z	160	3.0	10.5	2-Z	3.5	Attached to Bottom of Slave Deployer Reel Shaft (in axis)
	240	5.0	17.5	2-Z	3.5	
	700	4.5	19.5	2-Z	4.3	
Z-Z	148	5.0	7.5	10-Z	1.5	At C.G. of Slave Tip Mass (in axis)
	172	3.0	8.0	10-Z	2.7	
	212	5.0	17.8	10-Z	3.5	
	440	5.0	16.0	10-Z	3.2	
Z-Z	162	3.0	7.0	12-Z	2.3	Attached to Top of Master Deployer Reel Shaft (in axis)
	245	4.5	12.2	12-Z	2.7	
	640	4.5	14.5	12-Z	3.2	
Y-Y	140	2.3	12.0	6-X'	5.2	Side of Slave Tip Mass (18.5° Off Axis)
	200	5.0	14.5	6-X'	2.9	
Y-Y	375	5.0	21.0	7-Y'	4.2	End of Slave Tip Mass (18.5° Off Axis)
	470	4.5	15.5	7-Y'	3.4	
	660	4.6	14.5	7-Y'	3.2	
	700	4.6	14.5	7-Y'	3.2	
X-X	120	9.5(Max)	21.0	6-X'	2.2	Side of Slave Tip Mass (18.5° Off Axis)
	148	2.4	25.0	6-X'	10.4	
X-X	148	2.4	21.0	8-X'	8.7	Side of Master Tip Mass (18.5° Off Axis)
	200	5.0(Max)	15.0	8-X'	3.0	
X-X	148	2.4	16.0	9-X'	6.7	End of Slave Tip Mass (18.5° Off Axis)

Y-Y axis of the major points of interest. Thus, the data available for locations such as these in the X-X and Y-Y axes are of levels which are approximately 18.5 degrees off axis (This data is denoted by the X' any Y' notations). These input and response plots are presented in Appendix I.

3.1.3 Functional Testing

3.1.3.1 Previbration Functional Test Results

Prior to the vibration test, the prototype half-system was subjected to the prequalification functional test of section 5.0 through 5.10 of the Westinghouse qualification test procedure T789493. The prequalification functional test data obtained showed that the unit was not within the specified requirements of the Qualification Test Procedure for the ATS Boom/Deployer System T789493. These "out-of-spec" conditions were recorded on pages 38, 39 and 40 of the procedure T799493 in Appendix II. This data was in turn acceptable to the customer for use as the reference data for determining the environmental effects on the unit throughout the test program. Moreover, at a later date, similar deviations in the specifications and requirements of the flight units were considered acceptable by NASA/GSFC in letters of waiver for flight units S/N 0002 and S/N 0003. Copies of these letters of waiver can be found in Westinghouse document ATL-339, the ATS Gravity-Gradient Boom Flight Acceptance Test Report.

The unit was mechanically inspected prior to vibration testing and all discrepancies were noted in the log book. Engineering checks were also made during the vibration test and at times when the unit was not being actively vibrated. During one of these times, after shut down at 25 cps, while in the thrust axis of vibration, a portion of the clamping level screw that was not in the threaded portion of the tip mass assembly broke loose. This occurred while

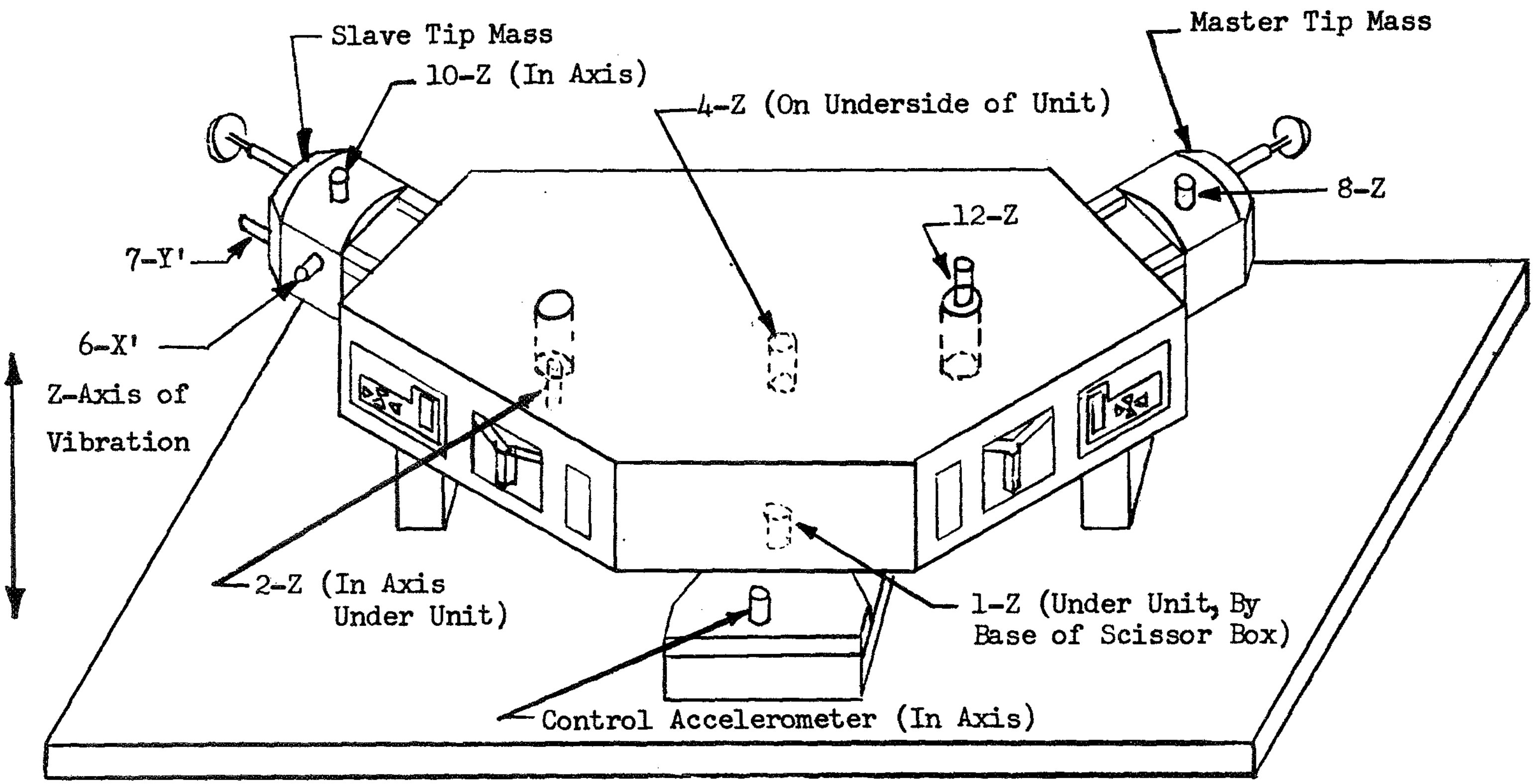


FIGURE 3-1

ACCELEROMETER LOCATIONS FOR THE THRUST (Z-Z) AXIS VIBRATION TEST

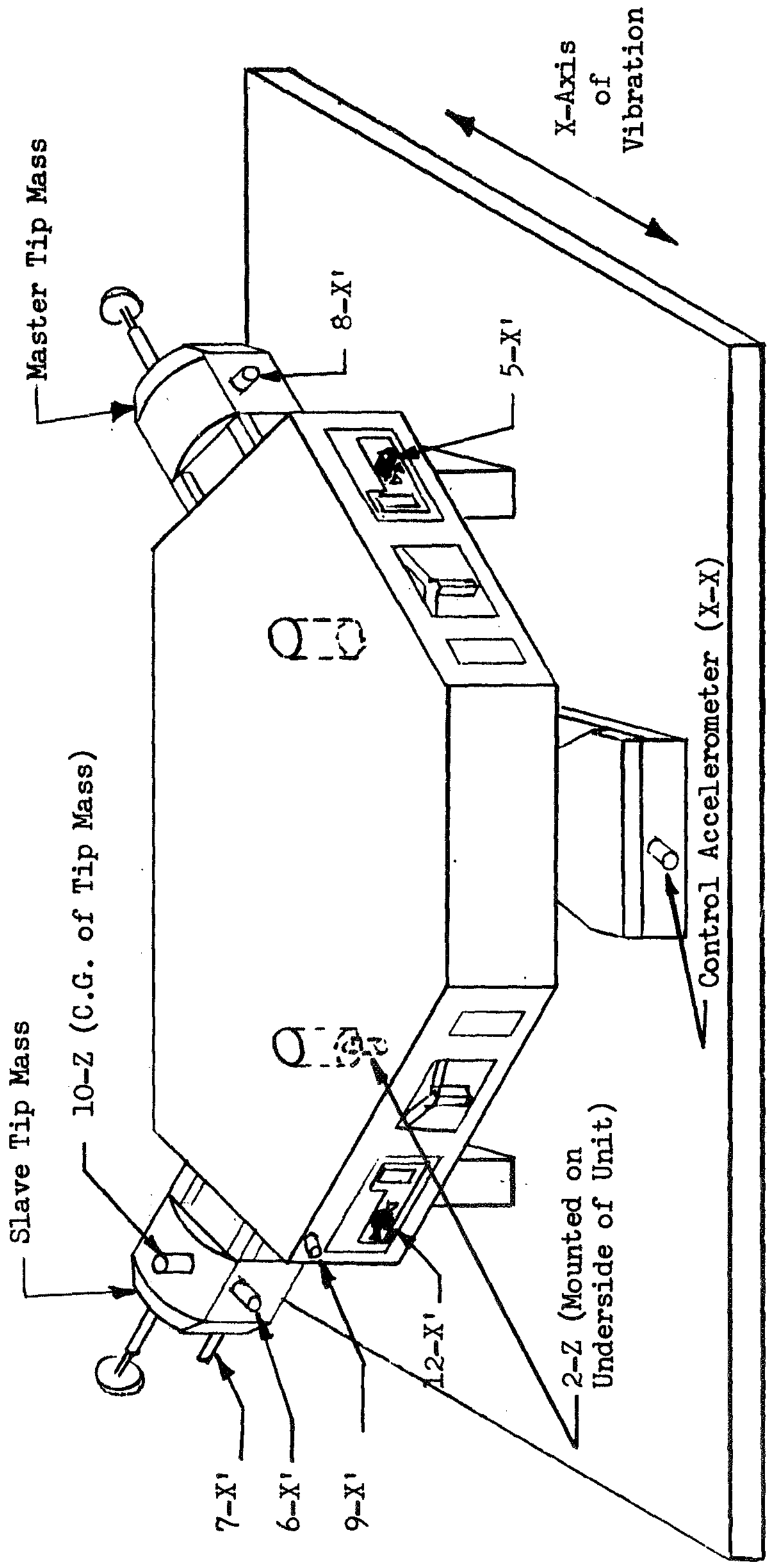


FIGURE 3-2

ACCELEROMETER LOCATIONS FOR X-X AXIS

VIBRATION TEST

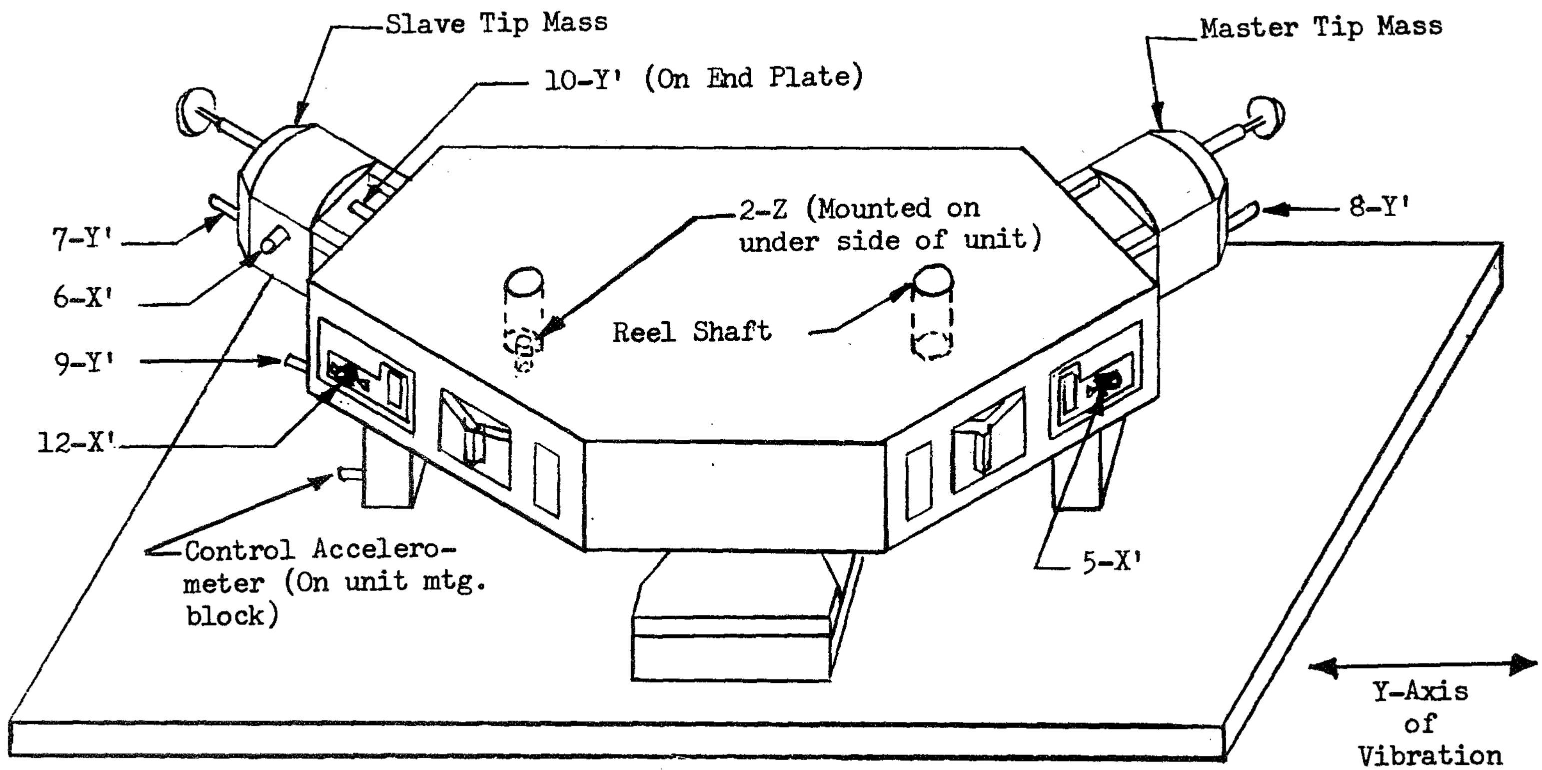


FIGURE 3-3

ACCELEROMETER LOCATIONS FOR THE Y-Y AXIS

VIBRATION TEST

the unit was mounted on the vibration system and when no pressures or forces were being exerted by any person examining the unit. Since 0.6 in. of the clamping screw remained in the unit and it was felt that the break would not affect the unit's operation,the testing continued. Postvibration mechanical inspection and tip mass release tests showed that the unit performed satisfactorily.

3.1.3.2 Postvibration Functional Test Results

The unit was subjected to the postvibration functional tests as prescribed by sections 9.1, 9.2, and 9.3 of the qualification test procedure T789493; i.e. the (1) tip mass release, (2) extension and retraction, and (3) scissoring tests, respectively. These tests were completed and all data was recorded on the appropriate data sheets in the qualification test procedure T789493 (Appendix II, pages 41 and 42). The results of this functional test showed no change in the deployment and scissoring parameters measured during the previbration functional test.

3.2 Acceleration Test Results

3.2.1 Resulting Design Modifications

No design modifications occurred as a result of the Acceleration test.

3.2.2 Acceleration Data

The data taken during the acceleration testing is presented in Appendix I and represents a plot of the revolutions per minute (RPM) of the centrifuge vs time. In order to obtain the required acceleration level of 22.6 g's, as specified in ATL 0246, the unit was placed so that its center of gravity was 44 inches from center of the centrifuge and rotated at 138 RPM.

3.2.3 Functional Testing

3.2.3.1 Preacceleration Functional Testing

As prescribed in ATL 0246, the results of the preacceleration functional test were also utilized as the postvibration functional test as recorded in Section 3.1.3.2 of this report.

3.2.3.2 Postacceleration Functional Testing

The postacceleration functional test consisted of the extension/retraction and scissoring testing (paragraphs 9.2 and 9.3 of T789493). The results of these tests were nominal and are presented on pages 42 and 43 of the qualification test data (Appendix II). In addition, it was decided to conduct a tip mass release test which was not required by T789493. Even though both the tip masses were released successfully, it was observed that the clamping lever on the slave tip mass release mechanism did not pivot as freely as it had originally or as the master clamping level was presently pivoting. It was felt that this discrepancy was not caused by the acceleration testing. No decision was made at that time as to what action should be taken relative to that observation.

3.3 Thermal-Vacuum Testing

3.3.1 Resulting Design Modifications

The design modifications that resulted from failures which occurred during thermal-vacuum testing are listed as Items 6 through 11 of Table 3.4-1.

3.3.2 Thermal-Vacuum Test Data

The data presented in Appendix I, is a sampling of the data obtained throughout the design-qualification thermal-vacuum testing. This data consists of the thermocouple and pressure readings during select times of testing such as tip mass release tests (cold and hot cases), extend, retract and scissoring tests. The occurrenceand time of the readings is noted with each entry. The thermocouple locations are indicated in Figure 3-4.

3.3.3 Functional Testing

3.3.3.1 Prethermal-Vacuum Functional Testing

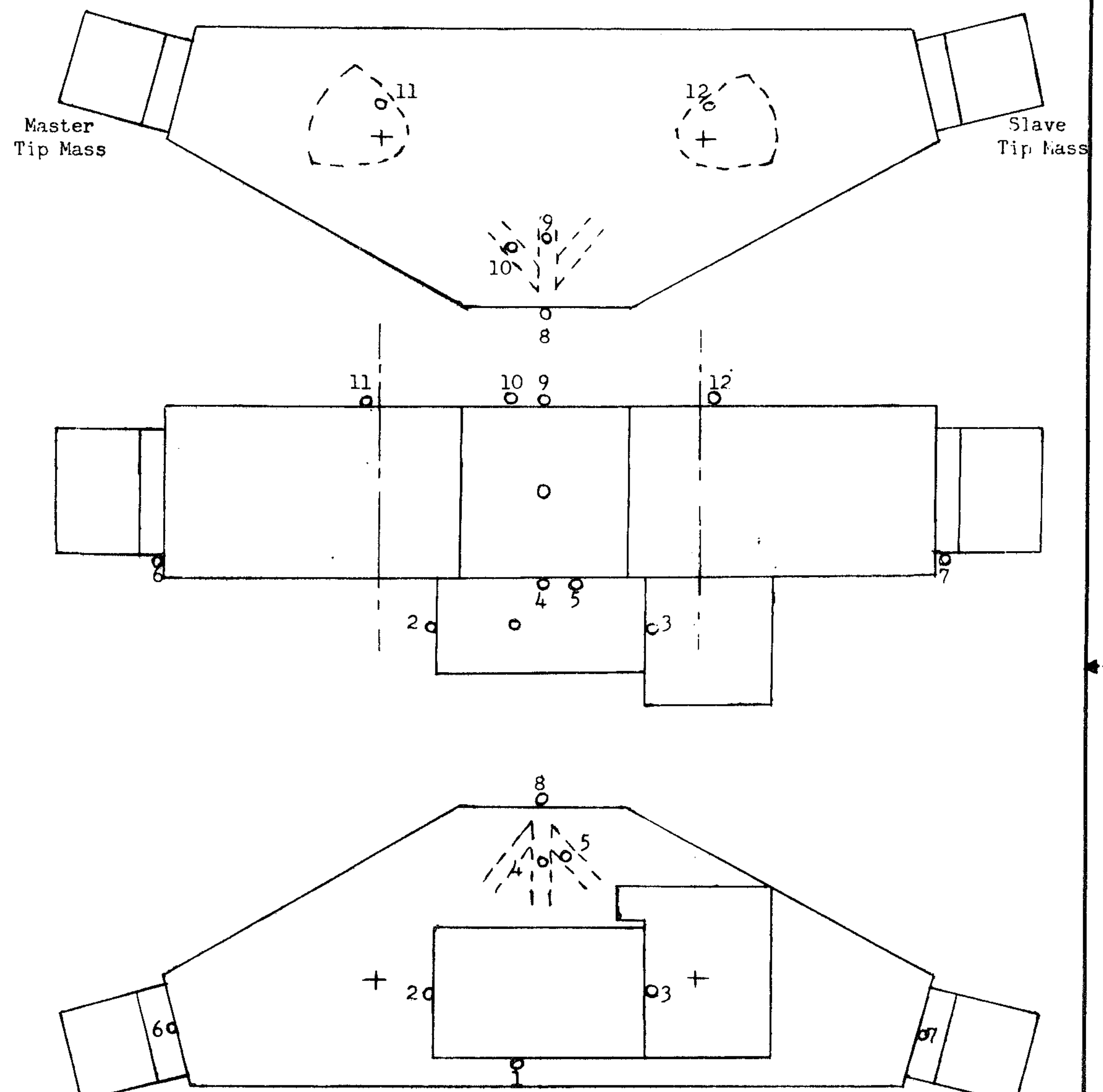
The results of the "Post Acceleration Functional Testing" in section 3.2.3.2 of this document are considered as the results of the prethermal-vacuum functional testing.

3.3.3.2 Tip Mass Release Testing During Thermal-Vacuum

During both of the thermal-vacuum T-M-R tests the unit mechanically performed satisfactorily with the tip masses being deployed between 2.5 and 4 inches each time. However, some electrical difficulties developed during these tests with the squib firing circuits. These discrepancies are indicated in Table 3.4-1, items 6, 7, and 8.

3.3.3.3. Extend, Retract and Scissoring Testing During Thermal Vacuum Testing

The ambient portion of the E/R & S performance test for the T/V testing was performed satisfactorily. Following this test, the unit was subjected to the first limited E/R & S testing at low temperature (-7.6°F Case). The extension and retraction portion was completed successfully. However a failure occurred during the scissoring testing. The analysis and corresponding corrective action are described in Table 3.4-1 Item 9. After resolving this failure the unit was again subjected to the low temperature-thermal vacuum testing. Upon retesting at -7.6°F, the unit operated satisfactorly during the first limited E-R & S test. However, during the second limited E/R & S test, the system failed to retract at 22 volts. The voltage had to be increased to 25 volts to complete the "22 volt



LOCATIONS OF THERMOCOUPLES
FOR THERMAL-VACUUM
QUALIFICATION TESTING
FIGURE 3-4

PAGE	CODE IDENT. NO.	SPECIFICATION NUMBER	REV
	97942		

BA 5656-3

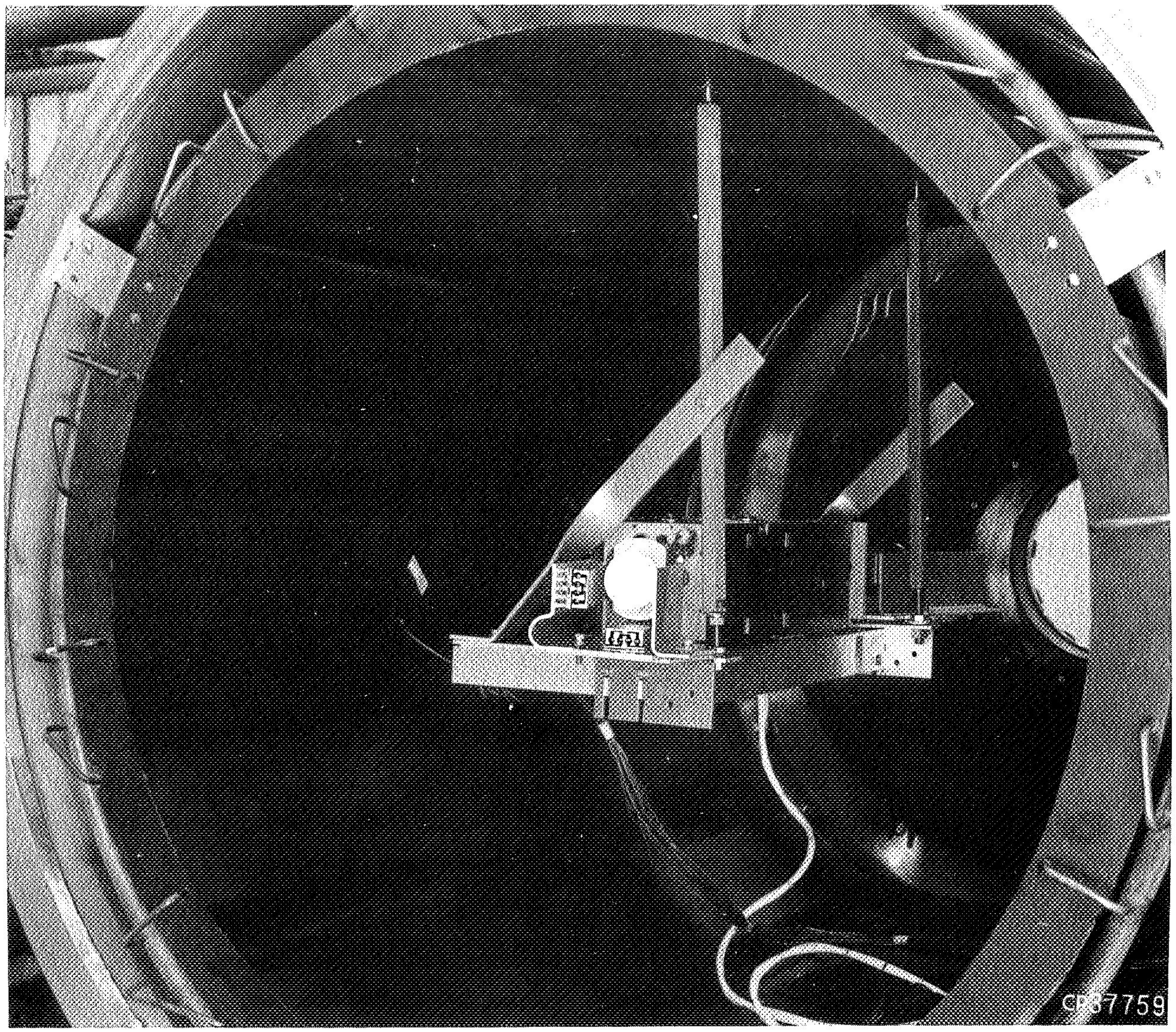


FIGURE 3-5
G/G BOOM SYSTEM MOUNTED ON THE TIP MASS RELEASE TEST FIXTURE
FOR THERMAL-VACUUM TESTING

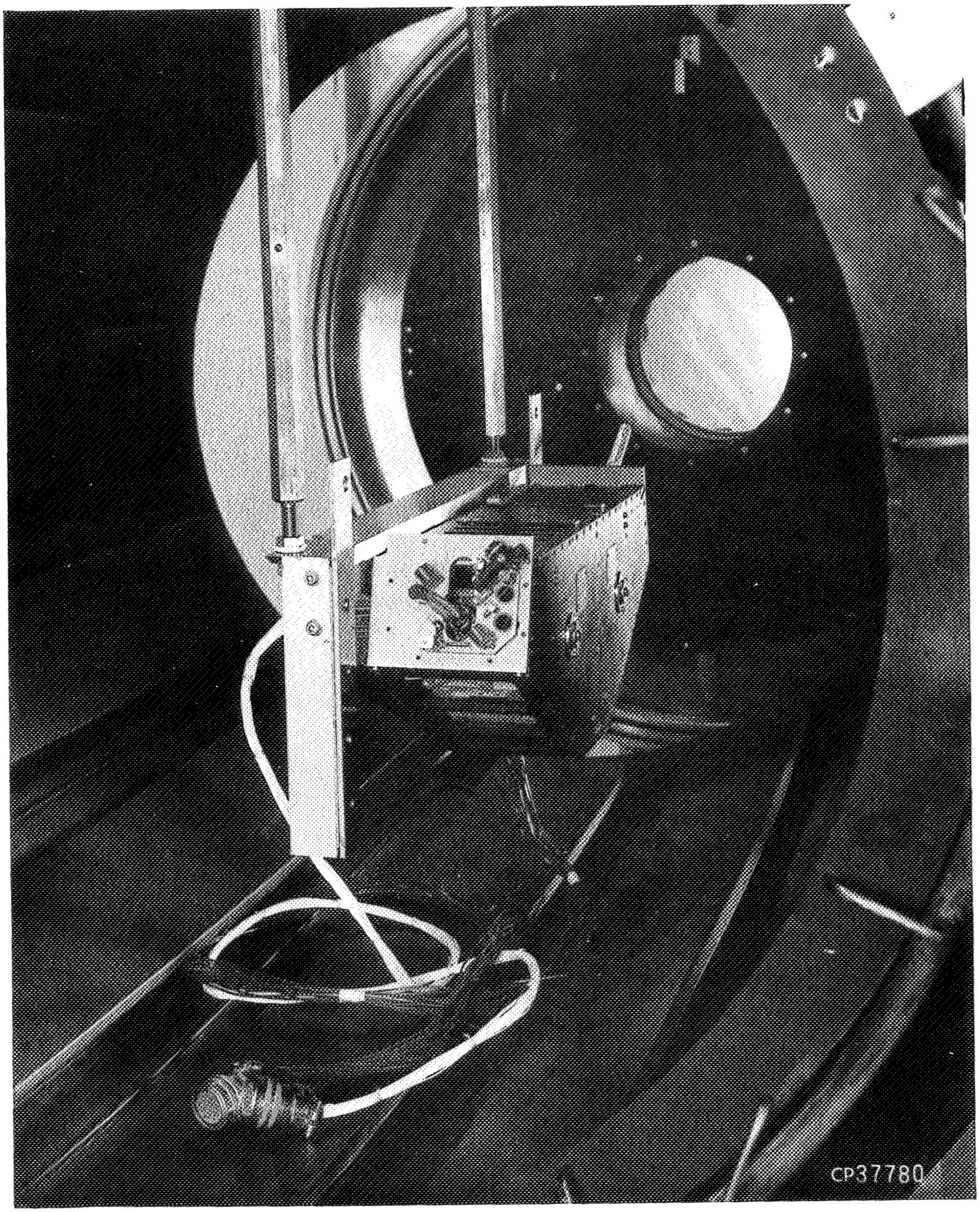


FIGURE 3-6
G/G BOOM SYSTEM MOUNTED ON THE TEST FIXTURE FOR THE LIMITED EXTENSION/RETRACTION AND SCISSORING TESTING IN THERMAL-VACUUM

portion" of the retraction phase of this testing. The results of the "30 volt portion" of the E/R & S test were satisfactory. The same results were obtained for the third, and final, limited E/R & S test except that "22 volt" retraction required 27 volts to complete.

The results of all three E/R & S tests of the high temperature case (139°F) were the same as those of the last E/R & S test of the low temperature case (-7.6°F) while in the required vacuum. (See above)

All of the results for the ambient and the low and high temperature thermal-vacuum E/R & S tests are presented in greater detail on pages 43 through 48 of the test specification T789493 of Appendix II.

3.3.3.4 Postthermal-Vacuum Functional Testing

The postthermal-vacuum test was performed with the order of testing changed (with NASA's verbal approval) to allow for deployment and scissoring first and to delete the leak test. The scissoring test was successfully performed. The 30 volt extension and retraction (with the slave boom being deployed down the test track) was nominal, as was the 22 volt extension. The booms retracted very slowly at 22 volts. The 30 volt extension and retraction and the 22 volt extension with the master boom being deployed down the tract were satisfactory. The system stopped retracting at 22 volts with approximately 40 feet of boom still down the track. The voltage was increased to 24 volts and the booms were successfully retracted. The remainder of the postthermal-vacuum functional testing was performed satisfactorily. The results of these functional tests are given on pages 51 and 52 of T789493 in Appendix II. Because the retraction portion of the postthermal-vacuum functional test as well as the retraction portion of the thermal-vacuum E/R & S testing were not performed satisfactorily at 22 volts, the unit was disassembled and examined carefully. It became apparent that the harmonic drive spline teeth had worn badly on the slave deployer. Since this was the 4th time that a slave deployer harmonic drive had failed, following approximately 3 hours of operating time (3 times in development testing) and since the harmonic drives of the master deployer had never failed during the same periods of operation, an investigation was made to determine some differences between the slave and master deployers which could have caused this "one sided" history of harmonic drive failures. A similar study had been made earlier and it was determined that differences in the harmonic drive alignment accuracies could have caused the slave harmonic drive failures encountered at that time. As a result, the critical harmonic drive alignments were defined and controlled so that both deployers went into qualification testing with their harmonic drives aligned per the established limits. With this in mind, these same alignments were checked to see if perhaps a change had occurred which would have been deterimental to slave deployer harmonic drive only. Measurements indicated that both harmonic drives retained their original alignments and if there was a difference, the master harmonic drive was not as well aligned as the slave harmonic drive. Careful measurements did indicate that the axial location of the slave harmonic drive wave generator was approximately .01 inches different from that of the master drive wave generator. It was felt that this difference was insignificant. No other pertinent differences in the two deployers were observed.

Since no apparent cause for the slave harmonic drive deterioration was discovered, it was decided to conduct as special test designed to determine a reasonable life expectancy for the flight unit harmonic drives. This decision was made after the two flight units had completed flight acceptance testing.

The two prototype harmonic drives were replaced by two (2) new harmonic drives. The alignment of each harmonic drive was checked prior to and after assembly into its deployer. The difference in the axial location, of the two (2) wave generators (as noted above) was eliminated. The prototype half system was then assembled and taken to NASA for the special harmonic drive test. The results of the special harmonic drive test were presented to the Launch Readiness Review Board of NASA/GSFC when considerations were being given to the flight acceptability of the previously tested flight units S/N 0002 and S/N 0003 of the G/G Boom System. At that time the Launch Readiness Review Board approved installing into the ATS-E Spacecraft, the flight units S/N 0002 and S/N 0003 of the G/G Boom System. The results of this Special Harmonic Drive Test are presented in Appendix II of this document.

3.4 Failures and Corrective Actions

The failures and corresponding corrective actions taken which occurred during the qualification test program of the G/G Boom System are chronologically listed in Table 3.4-1. Included in the table are the actual failures, the analysis, and the corrective actions taken as a result of the failures.

4.0 CONCLUSIONS

Based upon the waivers obtained from NASA/GSFC on the functional test data of the flight units, the results of the Special Harmonic Drive Test and with the addition of the design modifications incorporated during the vibration test, the ATS Gravity-Gradient Boom System is considered to have satisfactorily met the modified design performance requirements of Westinghouse documents T789493 and ATL 0246.

TABLE 3.4-1 FAILURES AND CORRECTIVE ACTIONS
OF QUALIFICATION TESTING

ITEM	FAILURE	ANALYSIS	CORRECTIVE ACTION
1. Qual. Vibration (Z-Z Axis) 12-10-68	The tip target broke off.	Design Failure Fatigue fracture of the threaded stud which secured the target.	The GFE tip target and adapter were abandoned. A "mock-up" of the tip target assembly was designed and built by Westinghouse for use in vibration tests.
2. Postqual. Vibration Functional Test Failure 12-12-68	Tip mass release mechanisms did not release when cables were manually cut.	Design Failure The support wheel had indented into the clamping lever contact surface. This caused the support arm to be locked in place.	Design Modifications The wheel diameter and thickness were increased. The support wheel and clamping lever were remade with harder materials. Another torsional spring was added on the support arm. A reference surface was added to the clamping lever to more accurately locate the wheel.
3. 2G Sinusoidal Vibration (Z-Z Axis) 1-3-69	Too much reel endplay.	Workmanship The set screw in the storage reel drive gear hub was improperly located during assembly.	Since the failure analysis was performed after the vibration test was completed, it was initially assumed that the set screw was at fault. Consequently a #8-32 panhead screw was threaded into the end of the shaft and drawn against the reel gear hub. The screw was locked in place using Loctite. This provided a redundant means of securing the gear to the shaft.
4. Qualification Sinusoidal Vibration (Thrust Axis) 1-7-69	Slave tip mass came off while increasing the G level to 12.5 G's at 25 Hz.	Design Failure The tip mass vibrated against its restraining structure which resulted from (1)Loosening of adjustment screw (2) Clamping elements were too rigid (3) Cable tension was not evenly distributed	Design Modifications The adjustment screw was locked in place with a spacer between the screw head and tip mass end plate. A more flexible clamping level was designed. Elements against which the cable rests were redesigned to more evenly distribute the cable load.

ITEM	FAILURE	ANALYSIS	CORRECTIVE ACTION
5. Postqualification Vibration Functional 1-29-69	Slave tip mass did not release.	Mislocation of the support wheel when brought against the reference surface on the clamping lever.	Limits of the allowable location of the wheel center were established; the positioning reference on the clamping level was redesigned.
6. Prethermal Vacuum Checkout 2-7-69 (This was not an official test)	Squibs failed to fire.	Workmanship error in wiring.	The Squib Connectors were rewired (RN #85655, Page 1 Item 2a).
7. Thermal-Vacuum Cold Case (1.6°F) T-M-R 2-9-69	Misinterpretation of telemetry data indicated that both tip masses were released but actually only one had been released.	Supplied test equipment gave different telemetry indications then expected.	Upon obtaining a better understanding of the supplied test equipment a revision was made to the test procedure concerning the expected telemetry indications in the tip mass release tests. (RN #B5621, Page 3, Item 16)
8. Thermal-Vacuum Cold Case (1.6°F) T-M-R 2-9-69	Squibs #2 & #4 did not fire during thermal-vacuum T-M-R test.	No definite cause was found. It was suspected that the firing commands were too short and the pulse had only time enough to fire one (1) squib on each side.	The squib firing commands were lengthened to one (1) second. RHB5621 Page 3 Item 16. Later, a one (1) shot 100 msec. pulser was used to fire the squibs.
9. Thermal-Vacuum at -22°C Extend, Retract & Scissoring Test 2-12-69	Scissoring Failure	Design Failure The roll pin securing the motor gear sheared off due to an excessive load caused by an interference between the potentiometer gear hub and a counterbore in the potentiometer bracket.	Design Modification The diameter of the counterbore in the potentiometer bracket for the gear hub was increased.

ITEM	FAILURE	ANALYSIS	CORRECTIVE ACTION
10. Thermal-Vacuum Extend, Retract, & Scissoring Test 2-20 to 2-22-69	The slave deployer would not operate in the retract mode 28 VDC.	Examination of the harmonic drive at the completion of the Qualification Testing showed that the harmonic drive of the slave deployer was in the early stages of failure during the T/V EXT-RET & SCIS. Testing.	Refer to Section 3.3.3.3 for Corrective Action.
11. Postthermal - Vacuum Functional 2-24-69	The unit would not retract.	The slave deployer harmonic drive teeth were worn severely which caused the system to fail to retract.	Refer to Section 3.3.3.4 for Corrective Action.

5.0 TEST REPORT SIGNATURES

A. Test Report Prepared By:

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J. W. Humphreys 12-23-69
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S. May
S. May, Program Manager
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W. W. Hill
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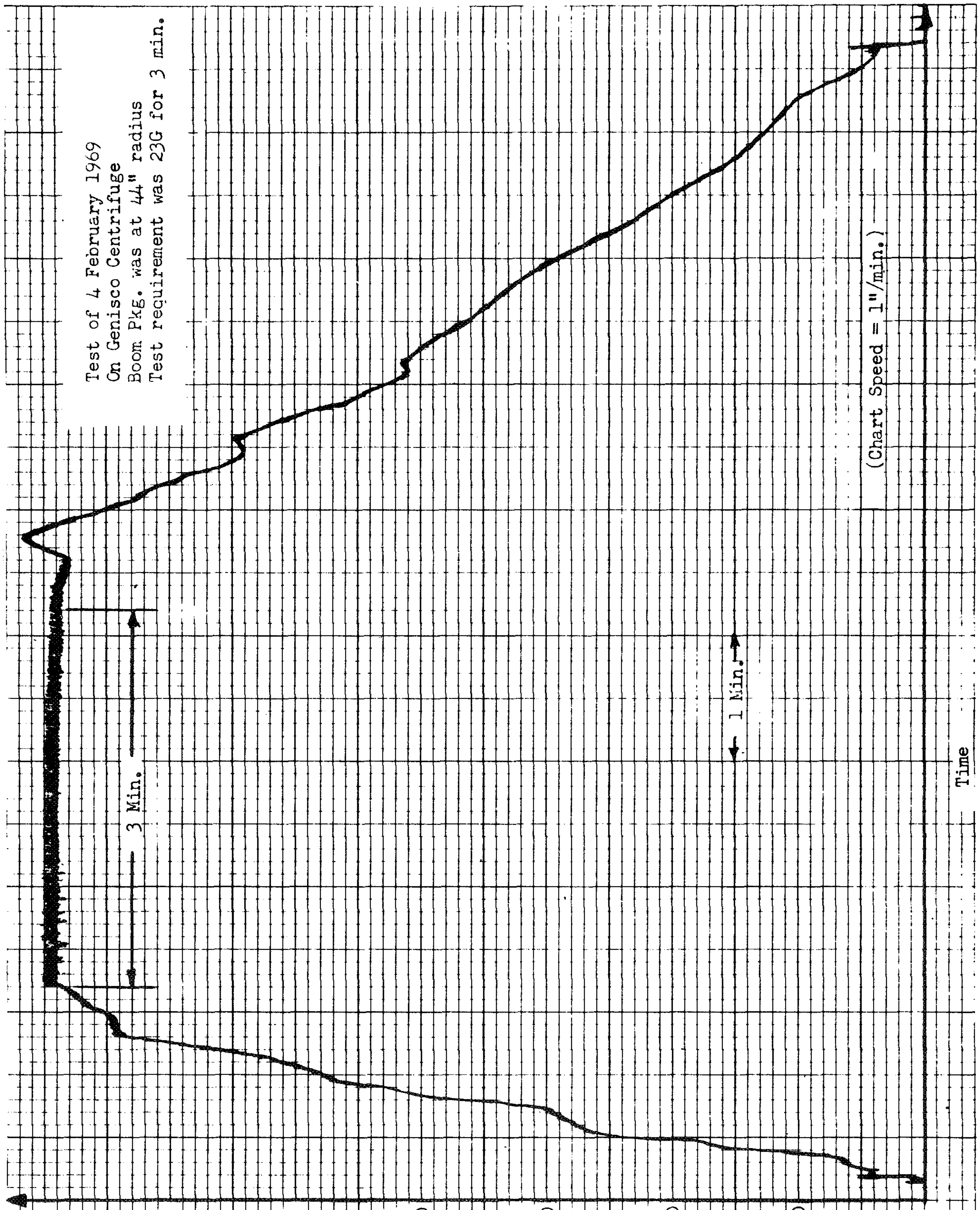
Aerospace Test Laboratory
Westinghouse Aerospace Division

APPENDIX I

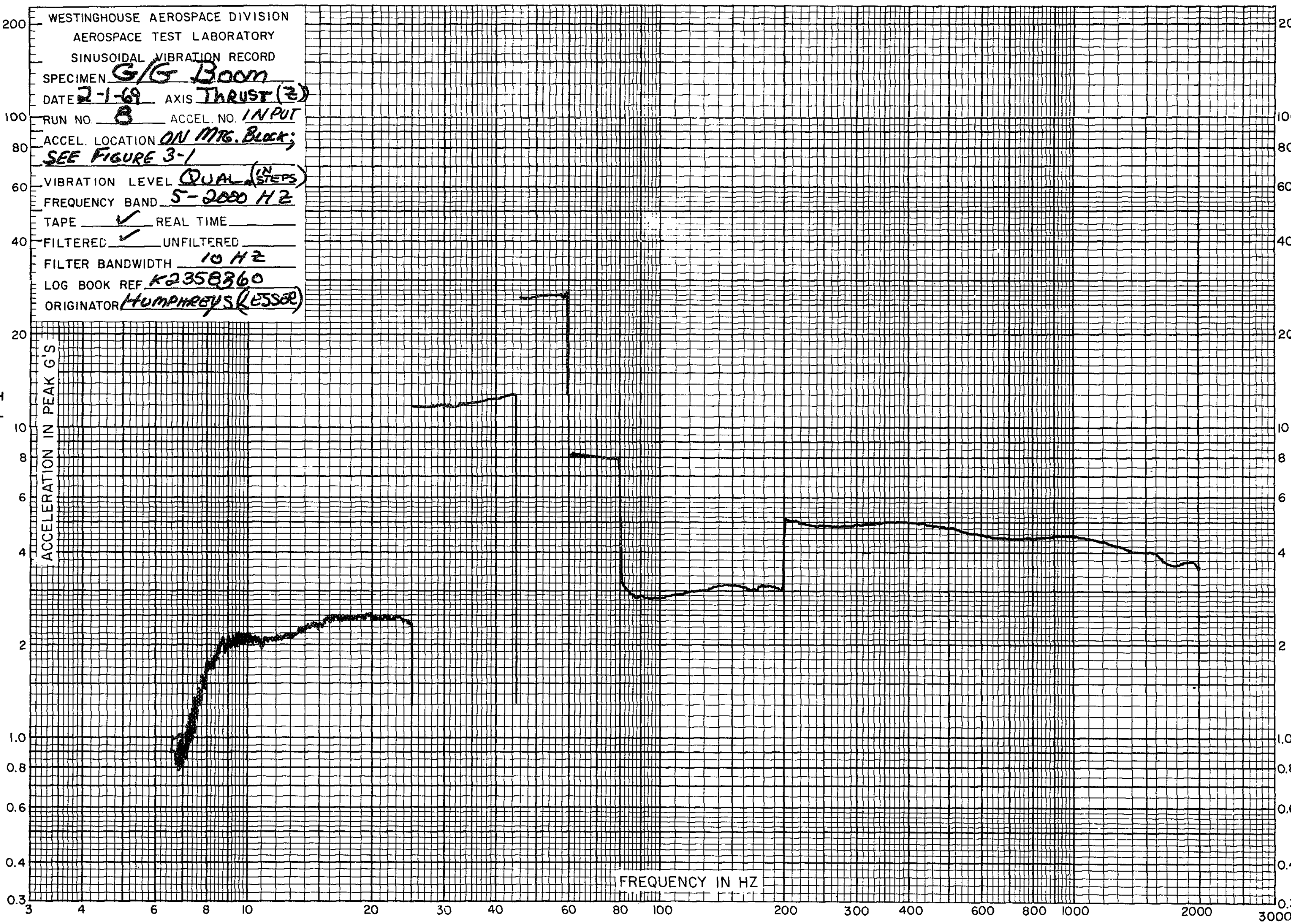
Environmental Test Data

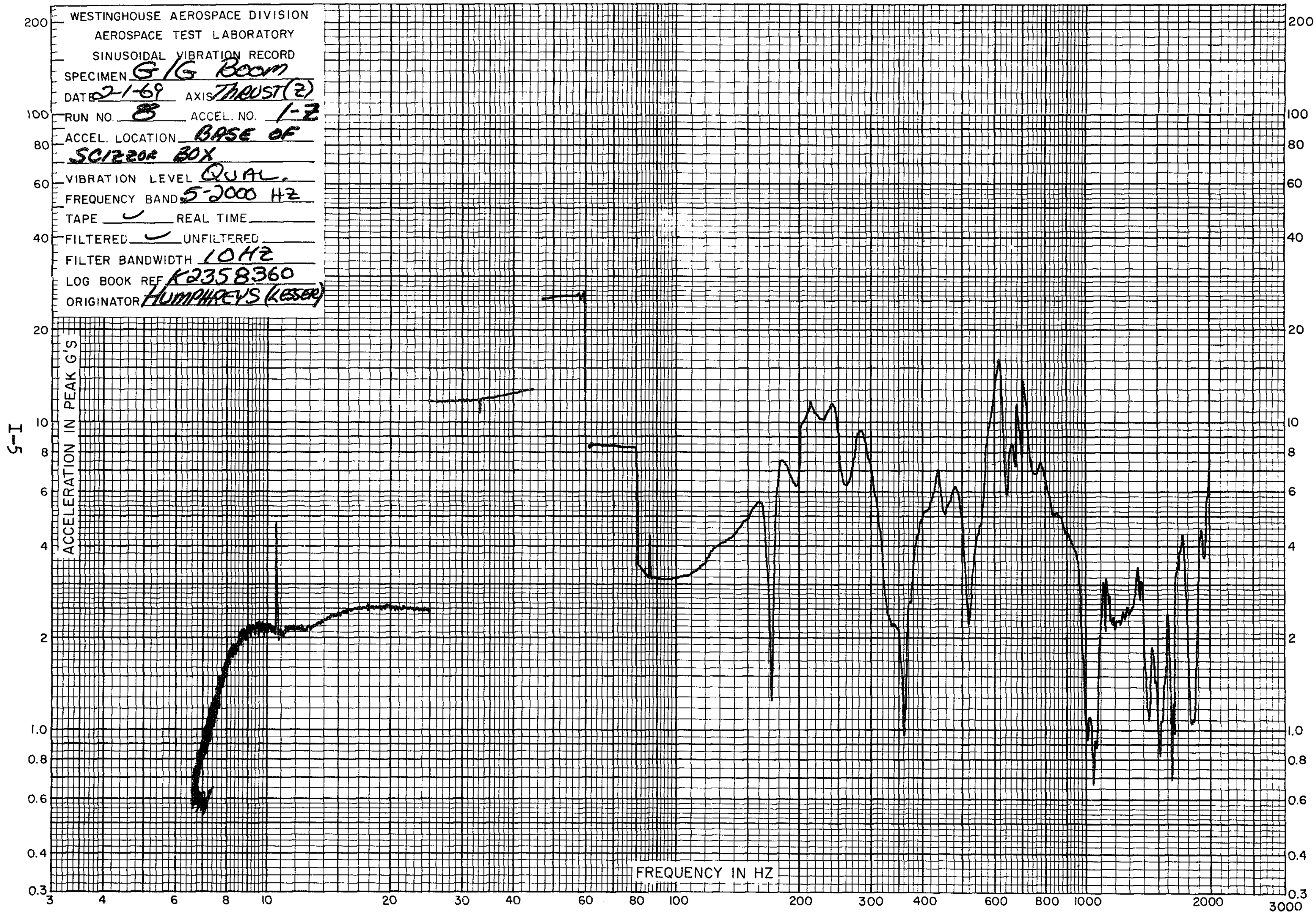
G/G Boom Qualification Unit Acceleration Test Data



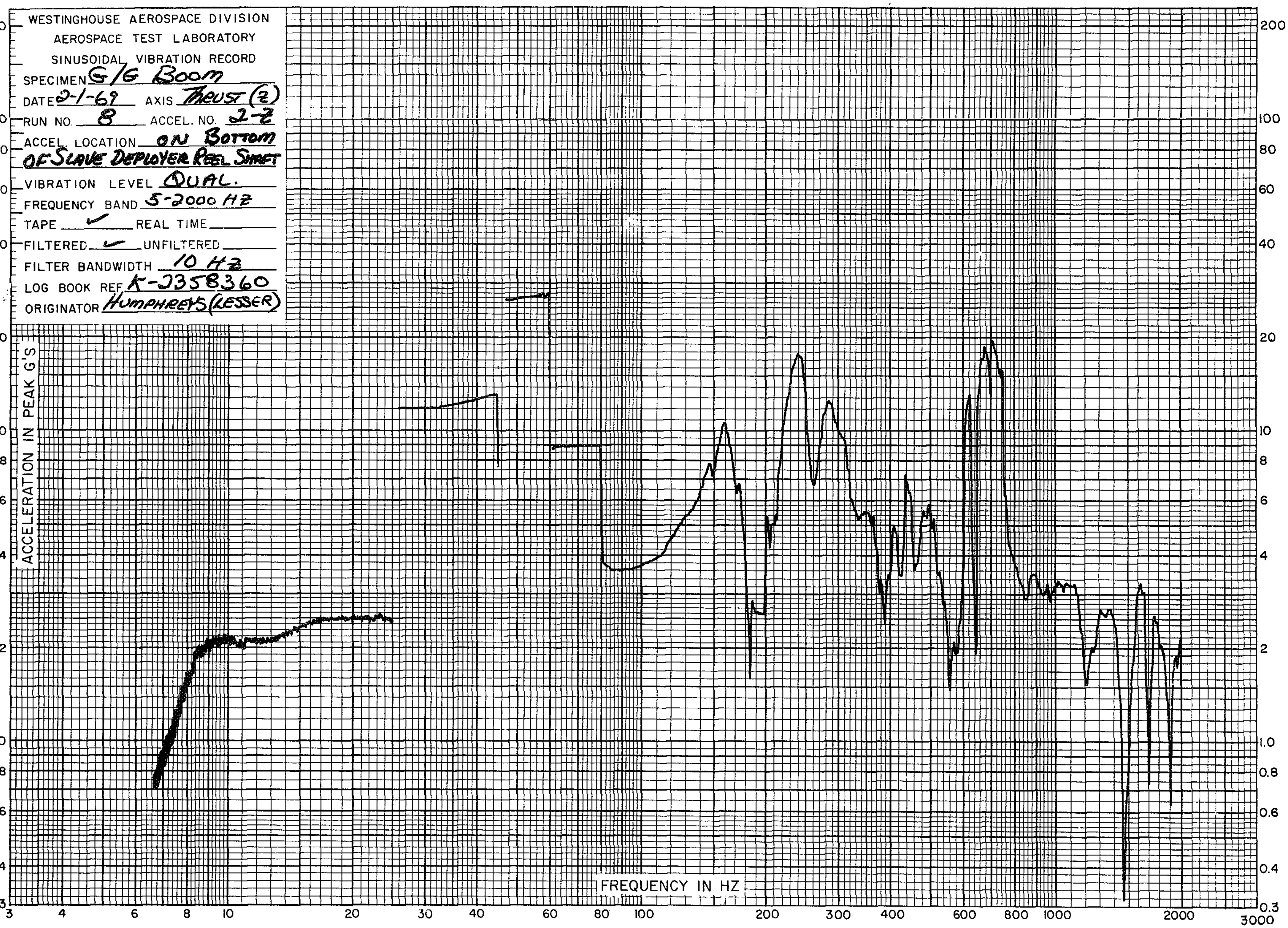
G/G Boom Qualification Unit Thermal-Vacuum Test Data

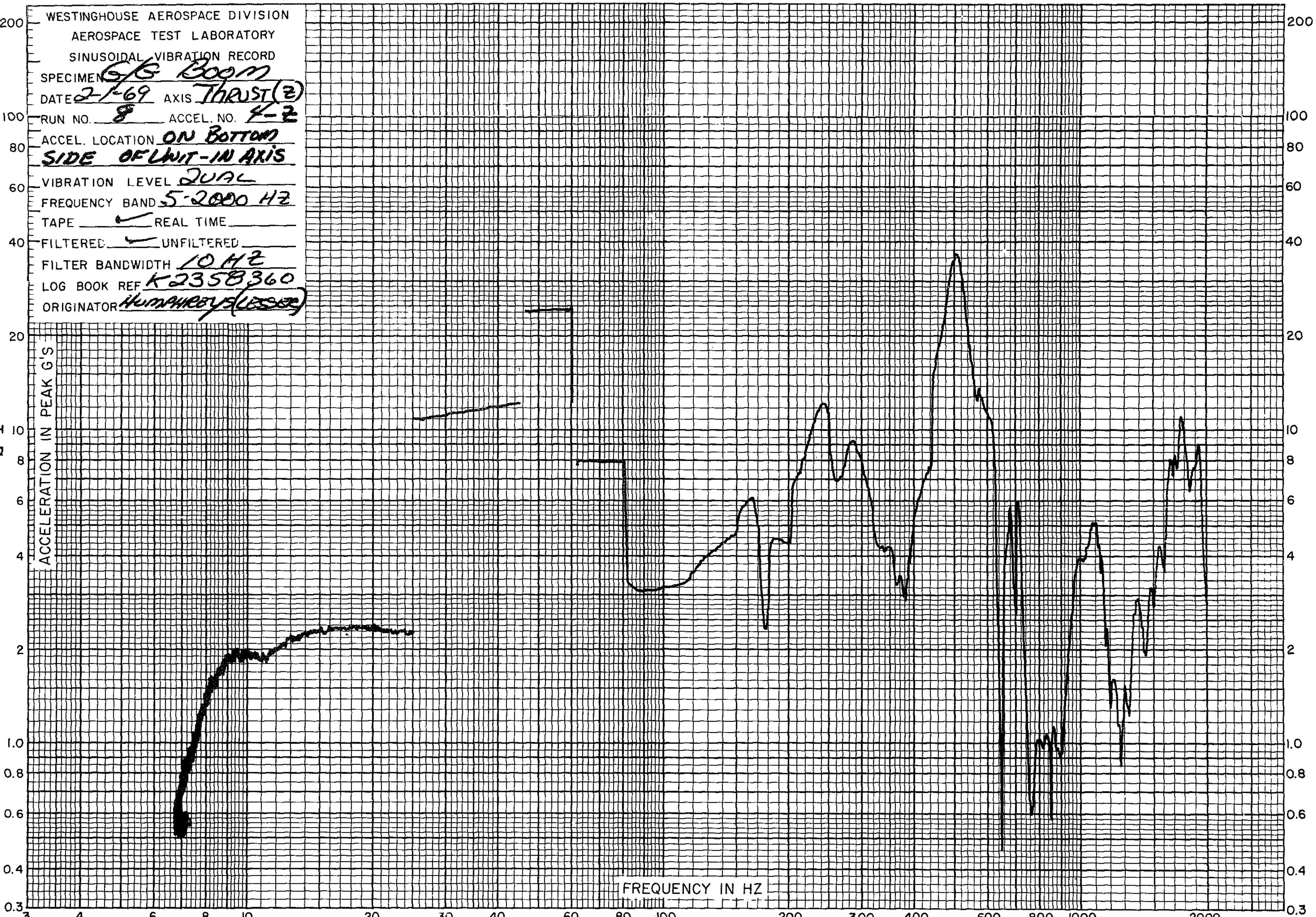
ITEM	DATE	EVENT	THERMOCOUPLE TEMPERATURES (°F)												TIME	PRESSURE
	1969		1	2	3	4	5	6	7	8	9	10	11	12	HRS.	mm. Hg.
1	2/8	Start of 6 hr. soak for TMR @ -30°C (-22°F)	-24	-24	-24	-22	-23	-22	-22	-22	-23	-24	-24	-24	0700	4.5×10^{-6}
2	2/8	Start of 18 hr. soak for TMR @ -17°C (+1.4°F)	2	2	2	1	2	1	1	0	1	2	2	1	1630	3.1×10^{-6}
3	2/9	End of 18 hr. soak @ -17°C (+1.4°F) @ time of TMR Functional (Cold Case)	1	1	1	1	1	2	2	2	1	1	1	1	1030	5.4×10^{-6}
4	2/10	Start of 24 hr. soak @ 60°C (139°F) for TMR test (Hot Case)	139	139	139	139	139	138	138	139	139	139	139	139	0400	1.0×10^{-5}
5	2/10	Out of Spec. Conditions during 24 hr. soak @ 60°C (139°F) (Hot Case) for 10 min.	139	140	140	140	140	139	140	140	140	140	139	140	1430	8.9×10^{-5} max.
6	2/11	End of 24 hr. soak @ 60°C (139°F) - Conditions held until functional	139	139	139	139	139	139	139	139	139	139	139	139	0400	6.9×10^{-6}
7	2/11	Prior to hot case TMR test. 60°C(140°F)	141	141	141	141	141	141	141	141	141	141	141	141	0830	7.0×10^{-6}
8	2/12	Start of 24 hr. soak for the E/R and S tests. First Functional (Scissor Failure)	-7	-7	-7	-6	-6	-6	-5	-5	-5	-5	-5	-5	1330	5.1×10^{-6}
9	2/19	Start of 24 hr. soak for the E/R and S tests. (Cold Case) First Functional -22°C(-7.6°)	-7	-6	-6	-5	-5	-5	-5	-6	-6	-6	-4	-5	1100	6.7×10^{-6}
10	2/20	Second Functional (E/R and S test) (-7.6°F)	-7	-7	-7	-6	-7	-6	-6	-7	-6	-6	-6	-6	0830	6.1×10^{-6}
11	2/20	Third Functional (E/R and S test) (-7.6°F)	-7	-7	-7	-5	-5	-5	-5	-5	-5	-5	-5	-5	1300	5.0×10^{-6}
12	2/21	Start 24 hr. soak for E/R and S test. (Hot Case) (140°F)	140	140	140	139	140	139	138	139	139	139	138	138	0630	6.2×10^{-6}
13	2/21	First Functional (E/R and S test) (140°F)	141	141	141	140	140	140	139	140	139	139	139	139	0830	6.4×10^{-6}
14	2/22	Second Functional (E/R and S test) (140°F)	141	141	141	141	141	140	139	140	139	139	139	139	1330	5.7×10^{-6}
15	2/22	Third Functional (E/R and S test) (140°F)	141	141	141	140	140	140	140	140	140	140	139	140	0830	5.2×10^{-6}
16	2/22	Ambient Engr. Check	77	79	78	80	81	80	80	79	80	79	80	79	1300	5.5×10^{-6}

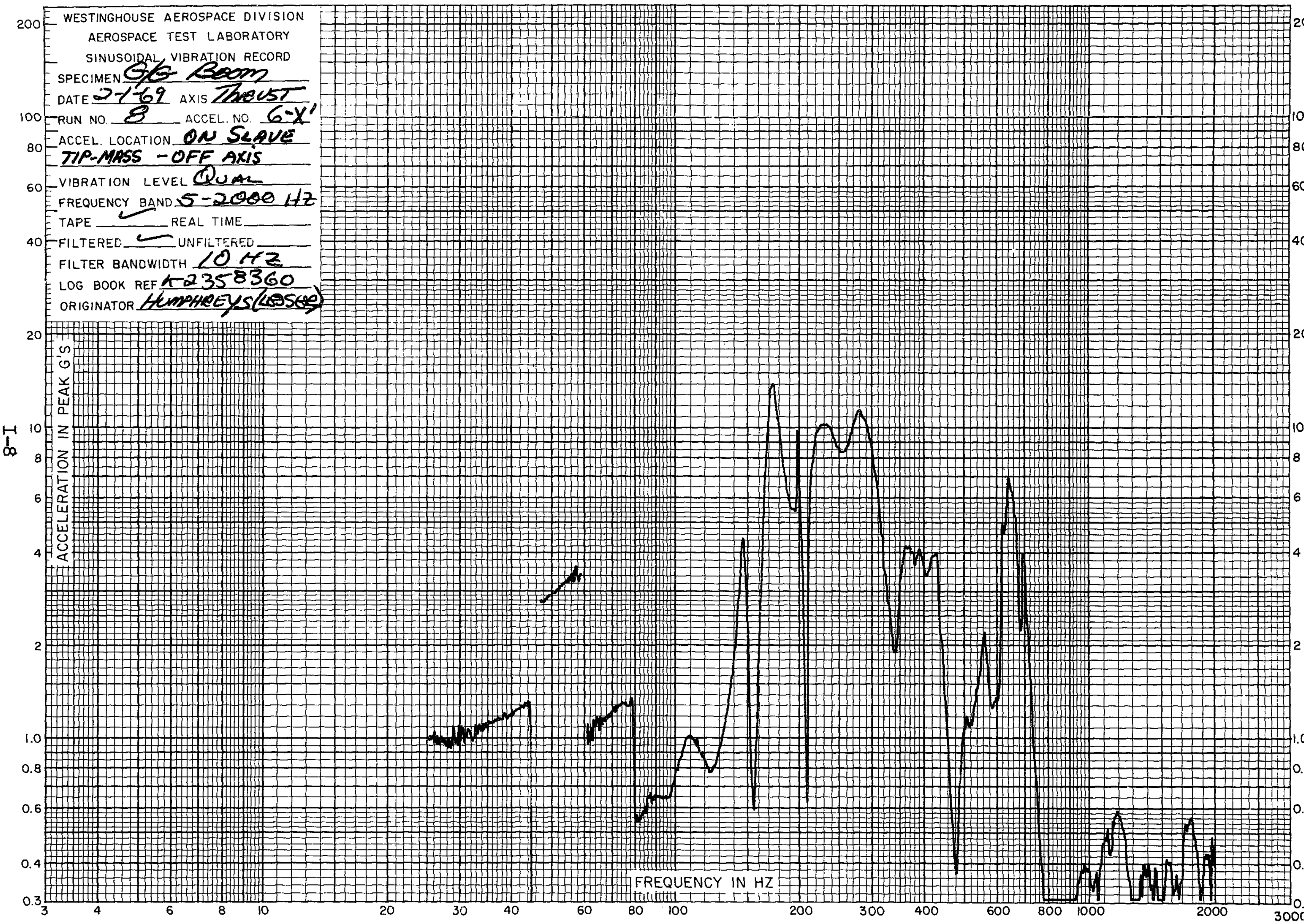

WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS THRUST (Z)
RUN NO. 8 ACCEL. NO. INPUT
ACCEL. LOCATION ON MTG. BLOCK; SEE FIGURE 3-1
VIBRATION LEVEL QUAL (IN STEPS)
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358360
ORIGINATOR HUMPHREYS (LESSOR)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ

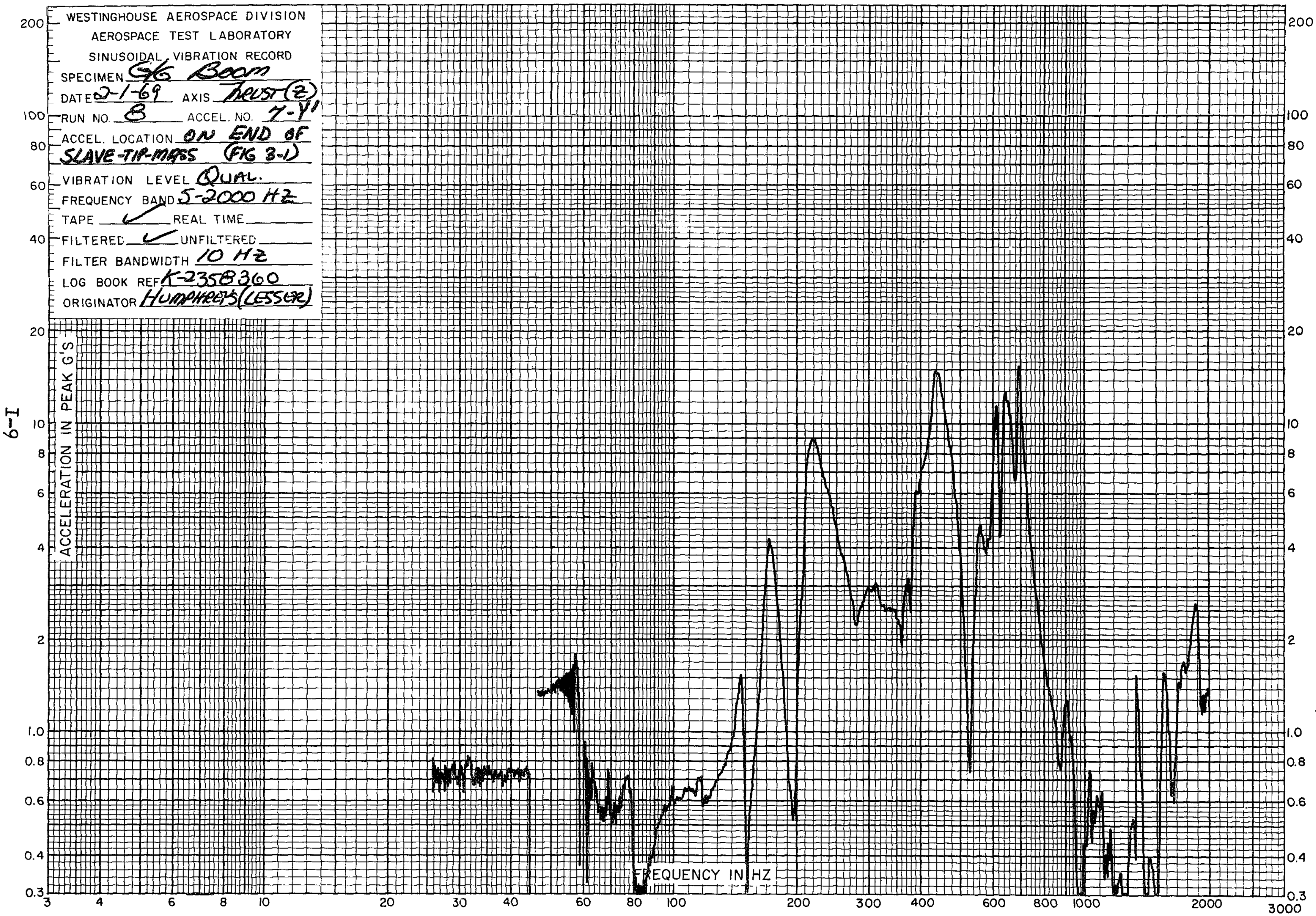


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS THRUST (Z)
RUN NO. 8 ACCEL. NO. 1-Z
ACCEL. LOCATION BASE OF SCIZZOR BOX
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10HZ
LOG BOOK REF K2358360
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G BOOM
DATE 2-1-69 AXIS THRUST (Z)
RUN NO. 8 ACCEL. NO. 2-Z
ACCEL. LOCATION ON BOTTOM OF SLAVE DEPLOYER REEL SHAFT
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358360
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS THRUST (Z)
RUN NO. 8 ACCEL. NO. 4-Z
ACCEL. LOCATION ON BOTTOM SIDE OF UNIT-IN AXIS
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358360
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS THRUST
RUN NO. 8 ACCEL. NO. 6-X'
ACCEL. LOCATION ON SLAVE
TIP-MASS - OFF AXIS
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358360
ORIGINATOR HUMPHREYS (LBS08)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ



WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS THRUST (Z)
RUN NO. 8 ACCEL. NO. 7-Y1
ACCEL. LOCATION ON END OF SLAVE-TIP-MASS (FIG 3-1)
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358360
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
100
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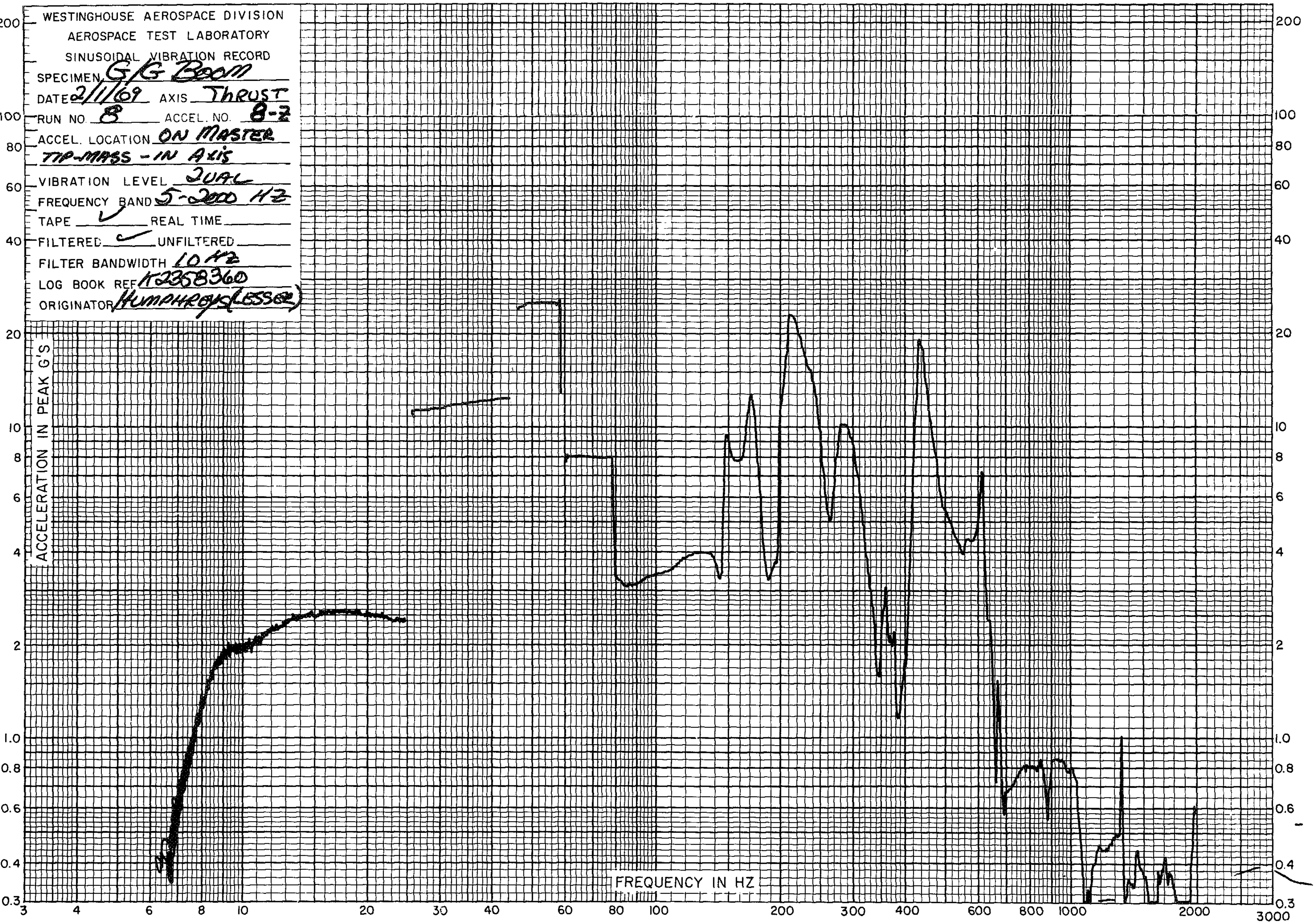
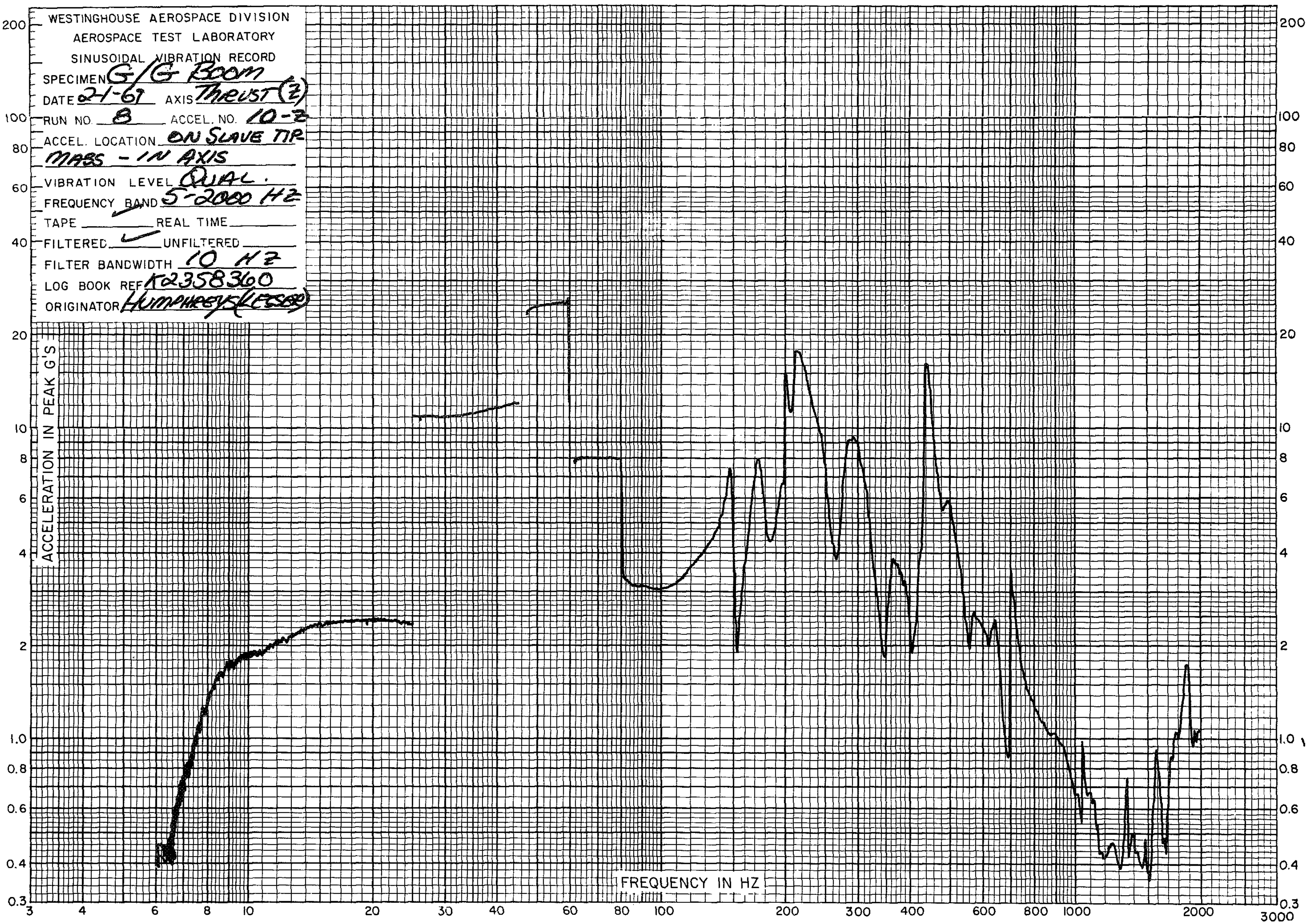


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2/11/69 AXIS Thrust
RUN NO. 8 ACCEL. NO. 8-2
ACCEL. LOCATION ON MASTER
TIP-MASS - IN AXIS
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 Hz
LOG BOOK REF K2358360
ORIGINATOR HUMPHREYS (LESSOR)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-67 AXIS THRUST (Z)
RUN NO. 8 ACCEL. NO. 10-Z
ACCEL. LOCATION ON SLAVE TIP
MASS - IN AXIS
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ___ REAL TIME ___
FILTERED ✓ UNFILTERED ___
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358360
ORIGINATOR HUMPHREYS (LESAP)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
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80
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6
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1.0
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0.6
0.4
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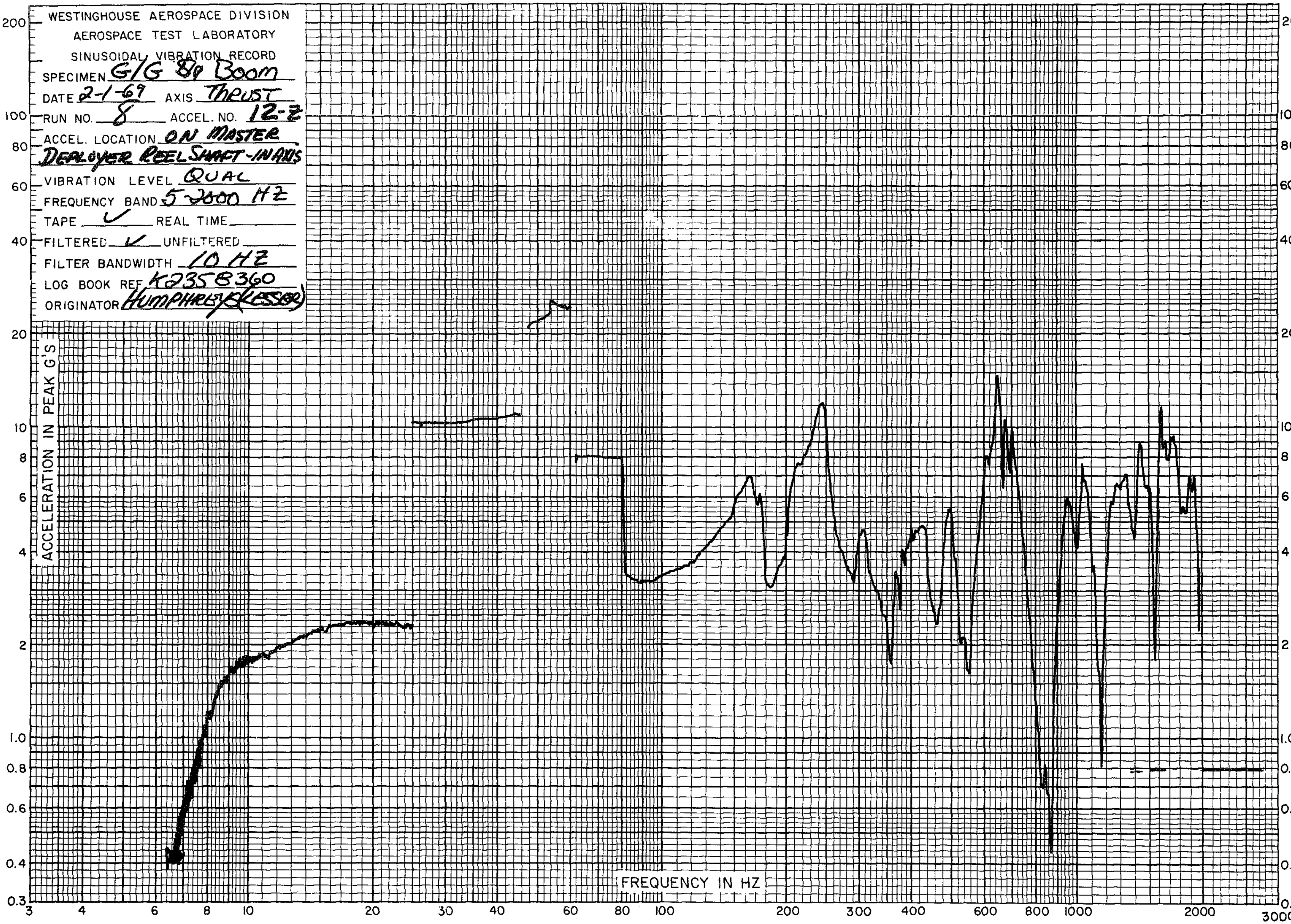
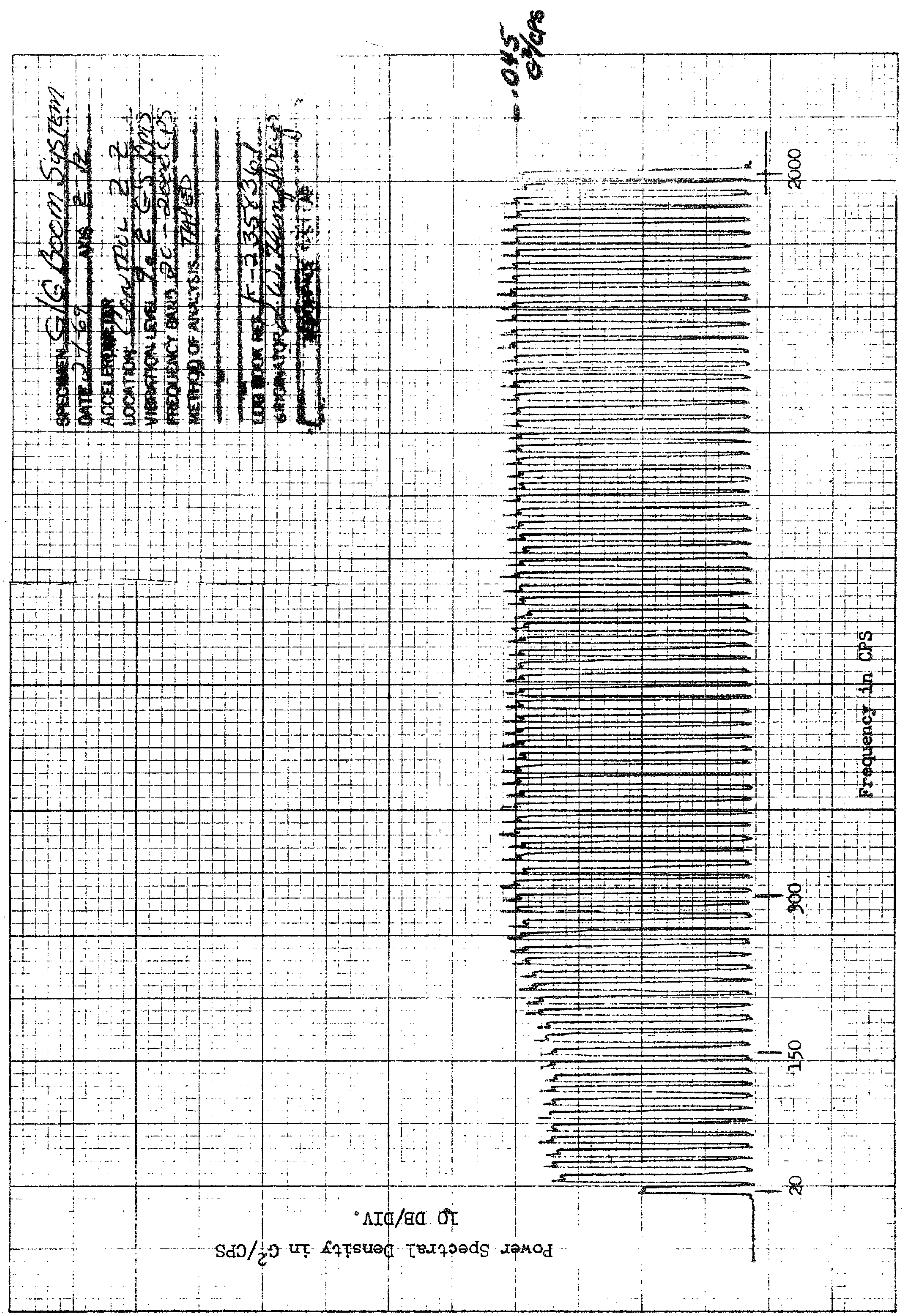
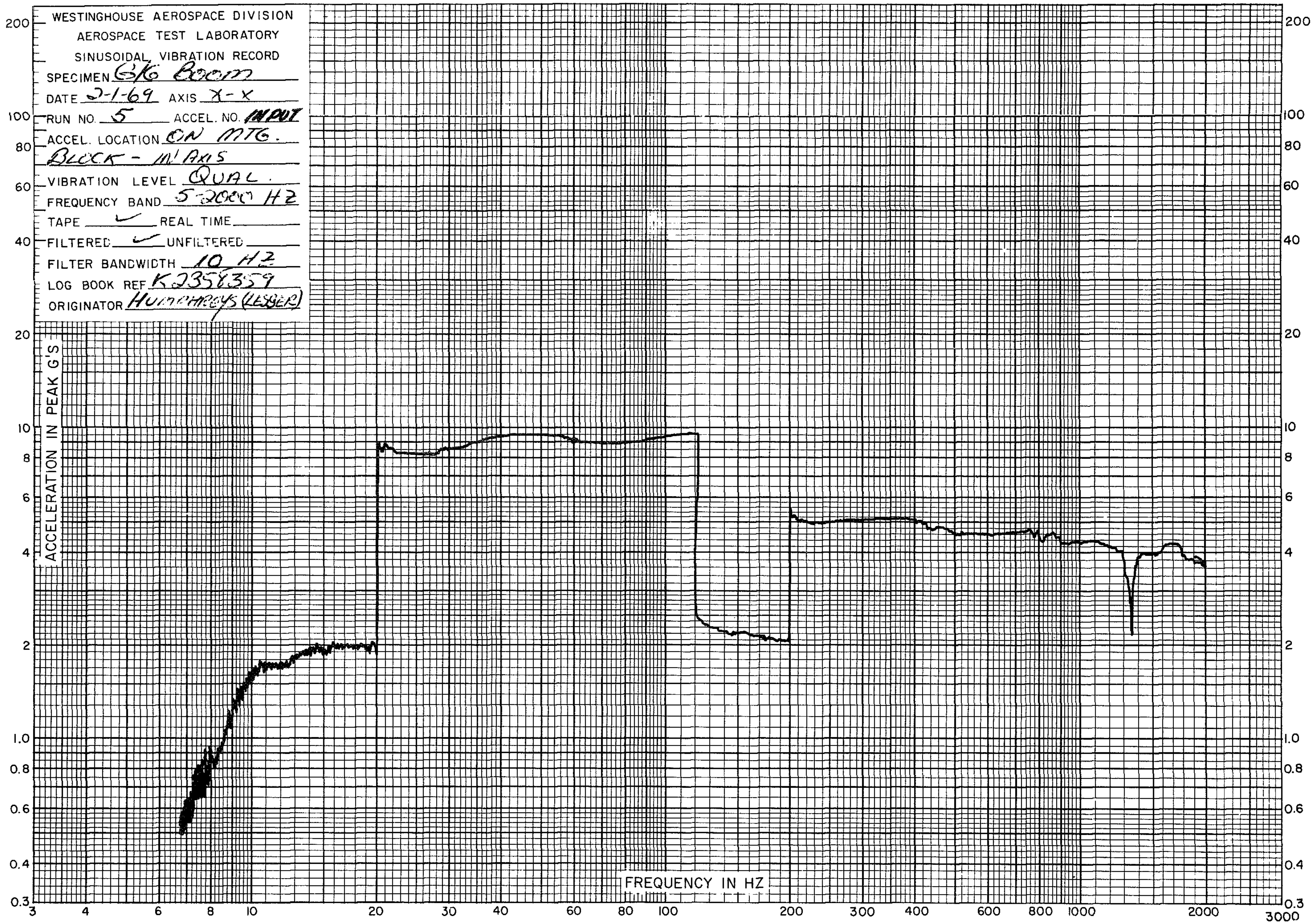
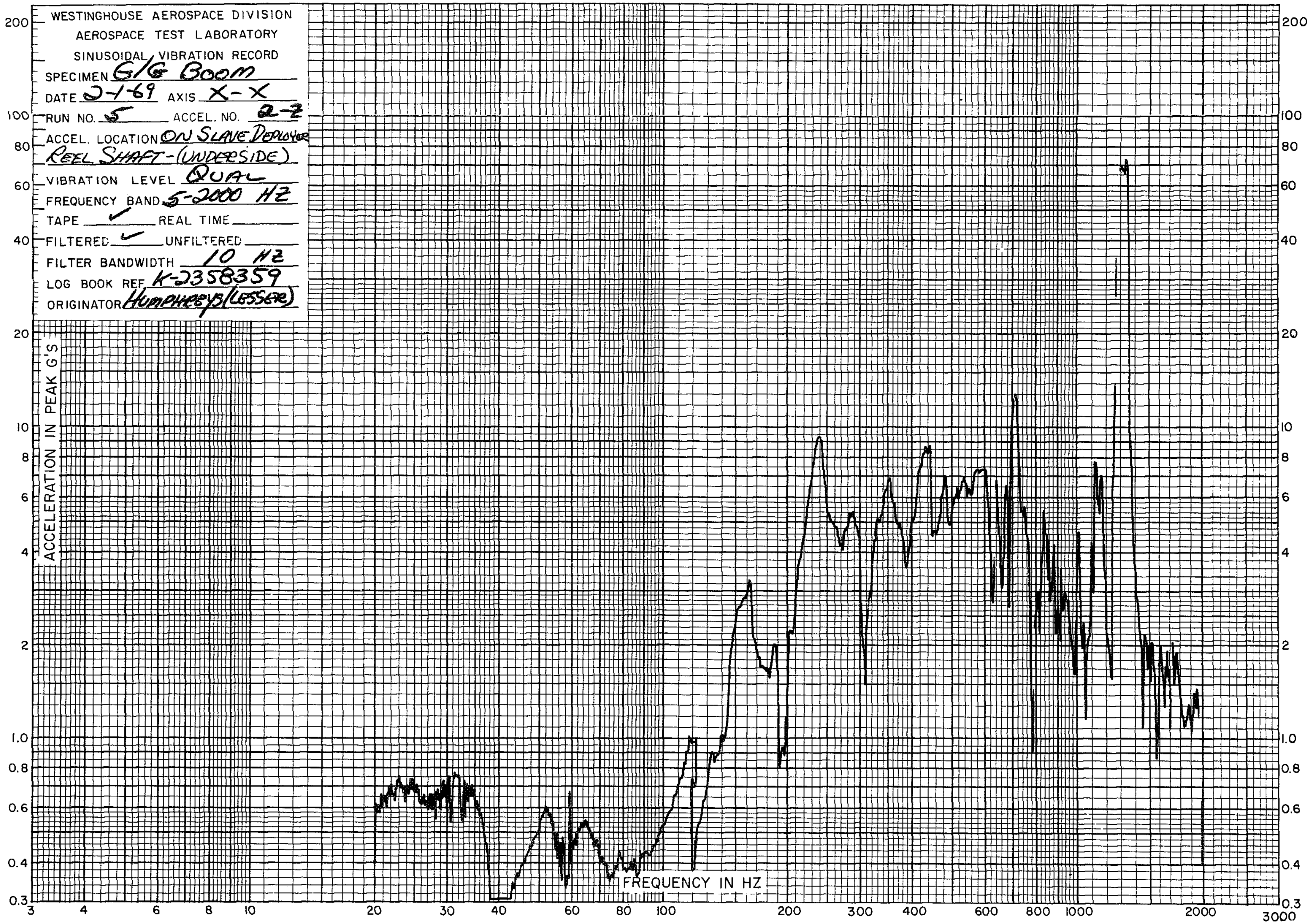

WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G 8ft Boom
DATE 2-1-69 AXIS THRUST
RUN NO. 8 ACCEL. NO. 12-Z
ACCEL. LOCATION ON MASTER DEPLOYER REEL SHAFT-IN AXIS
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K235 B360
ORIGINATOR HUMPHREYS (KESSOR)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


SPECIMEN G/G Boom System
DATE
ACCELEROMETER
LOCATION
VIBRATION LEVEL
FREQUENCY BAND
METHOD OF ANALYSIS TAPED
LOG BOOK NO.
OPERATOR
.045 G²/CPS
2000
900
150
20
Frequency in CPS
Power Spectral Density in G²/CPS
10 DB/DIV.


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. INPUT
ACCEL. LOCATION ON MTG.
BLOCK - M' AXIS
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358359
ORIGINATOR HUMPHREYS (LESBER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL/VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. 2-Z
ACCEL. LOCATION ON SLAVE DEPLOYER REEL SHAFT-(UNDERSIDE)
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358359
ORIGINATOR HUMPHREYS(LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
100
80
60
40
20
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8
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4
2
1.0
0.8
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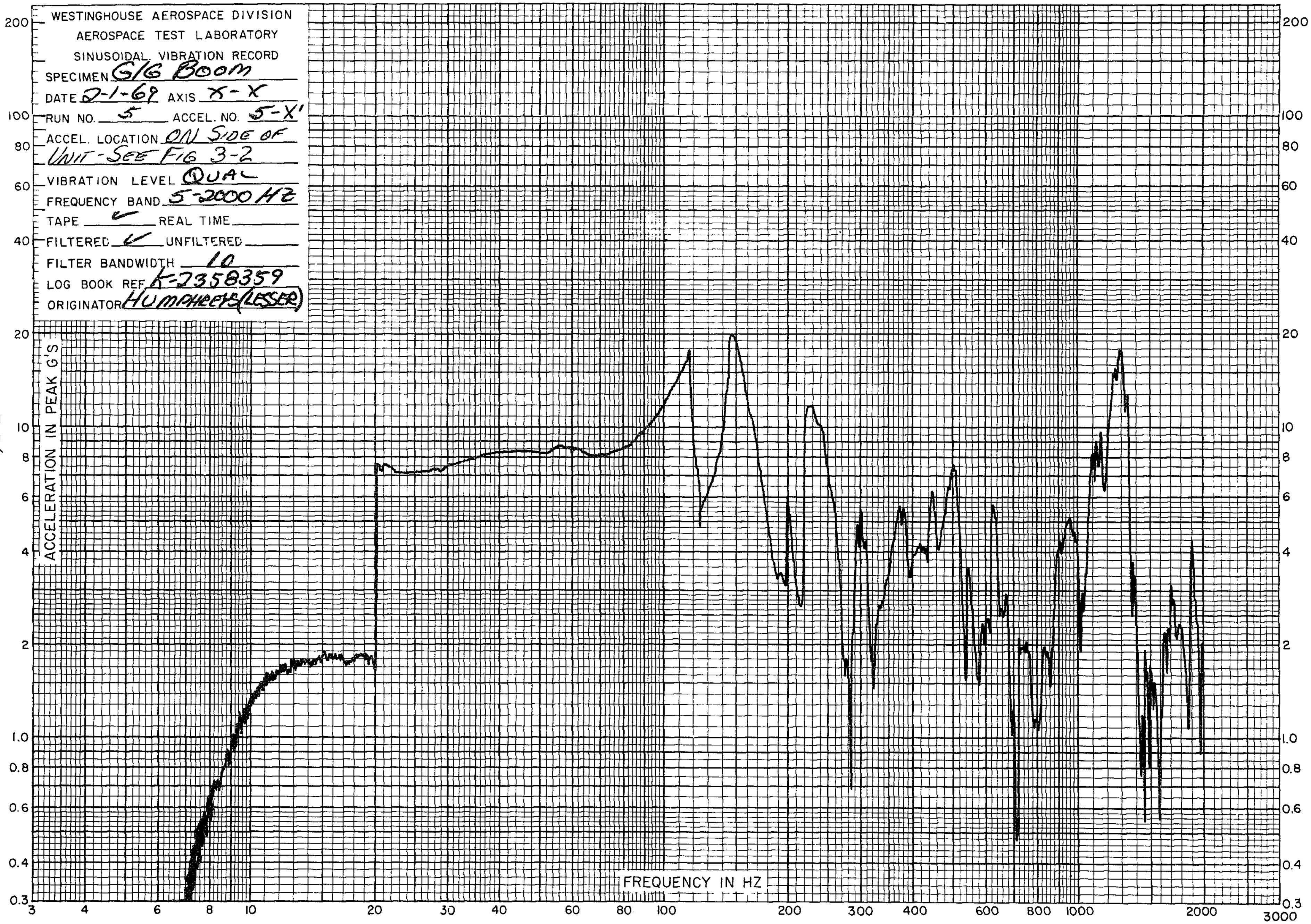
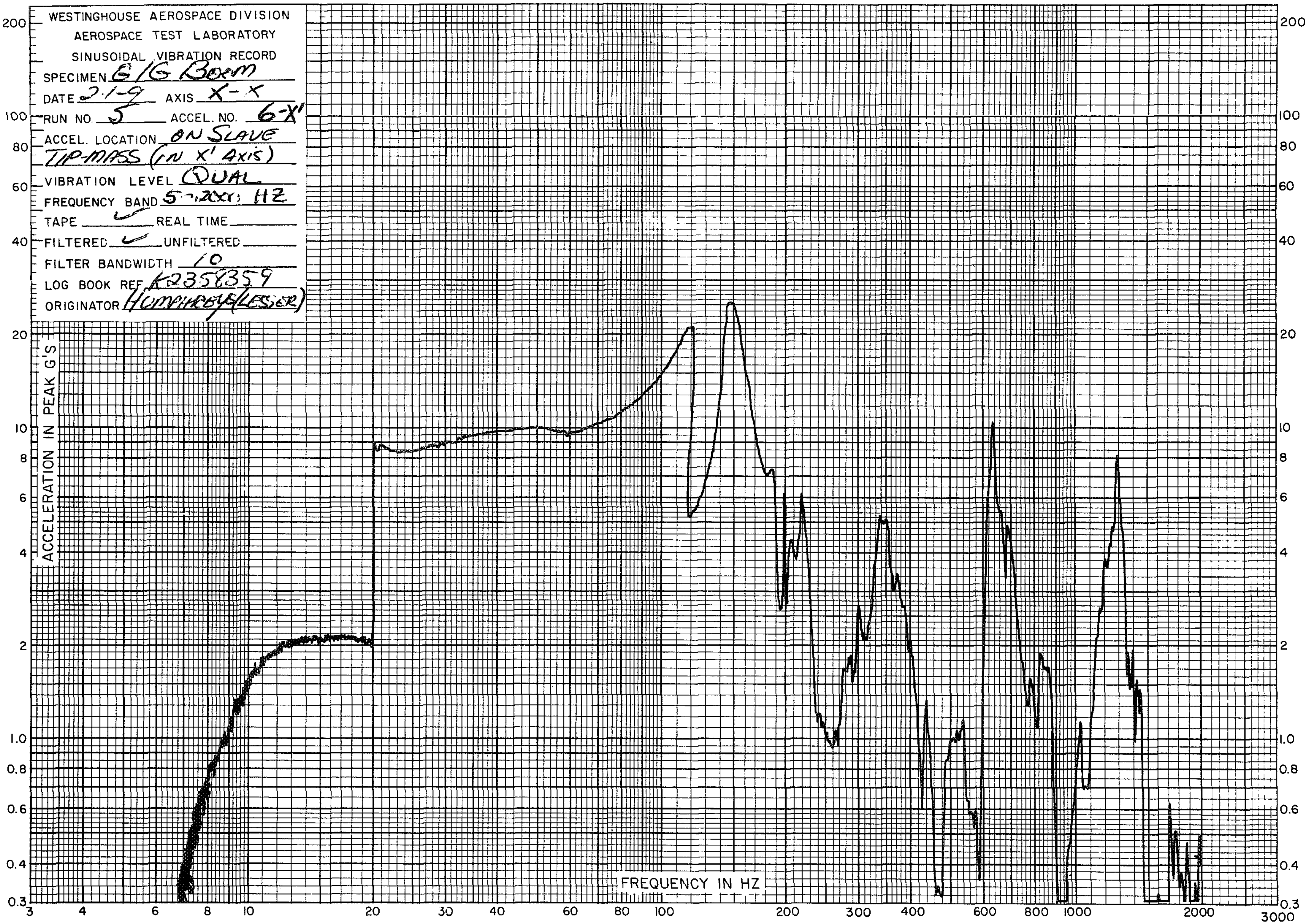

WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. 5-X'
ACCEL. LOCATION ON SIDE OF UNIT-SEE FIG 3-2
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10
LOG BOOK REF K-2358359
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN E/G Boom
DATE 2-1-9 AXIS X-X
RUN NO. 5 ACCEL. NO. 6-X'
ACCEL. LOCATION ON SLAVE
TIP-MASS (IN X' AXIS)
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10
LOG BOOK REF K2358359
ORIGINATOR HUMPHREYS/LESSER
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
100
80
60
40
20
10
8
6
4
2
1.0
0.8
0.6
0.4
0.3
3
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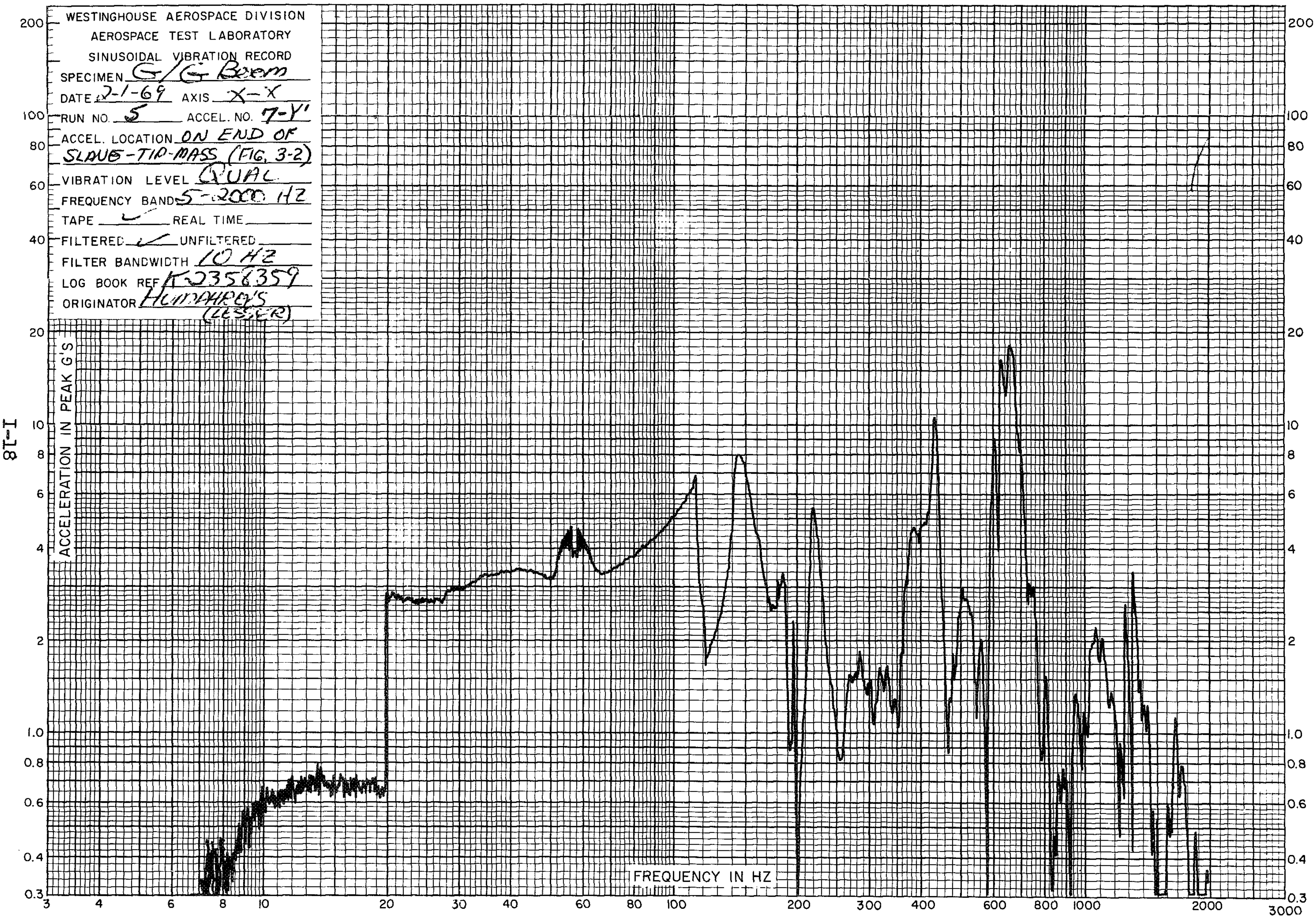

WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. 7-Y'
ACCEL. LOCATION ON END OF SLAVE-TIP-MASS (FIG. 3-2)
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358359
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
100
80
60
40
20
10
8
6
4
2
1.0
0.8
0.6
0.4
0.3
3
4
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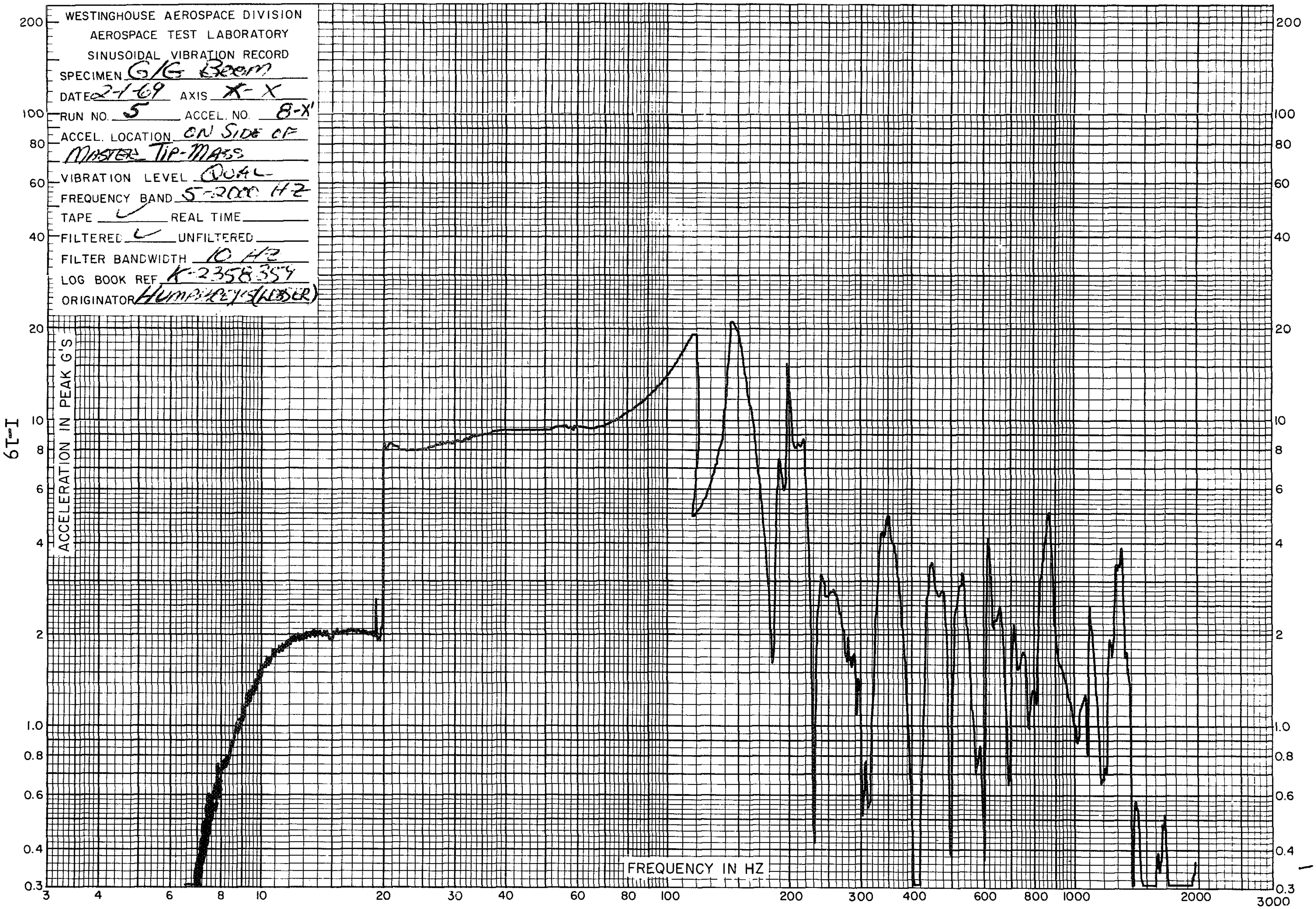
WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Beam
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. 8-X'
ACCEL. LOCATION ON SIDE OF MASTER TIP-MASS
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358354
ORIGINATOR HUMPHREYS (LOSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
100
80
60
40
20
10
8
6
4
2
1.0
0.8
0.6
0.4
0.3
3
4
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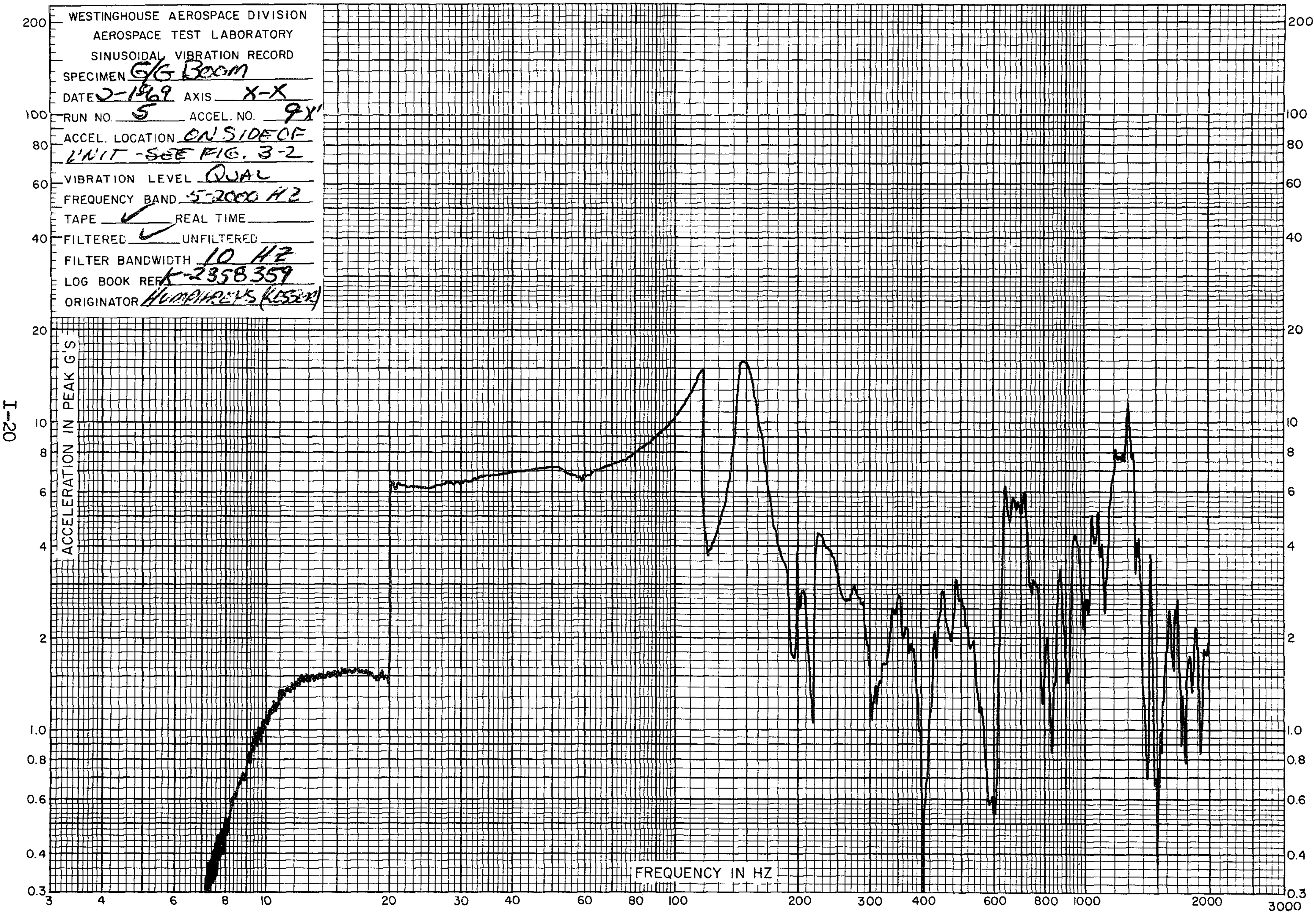
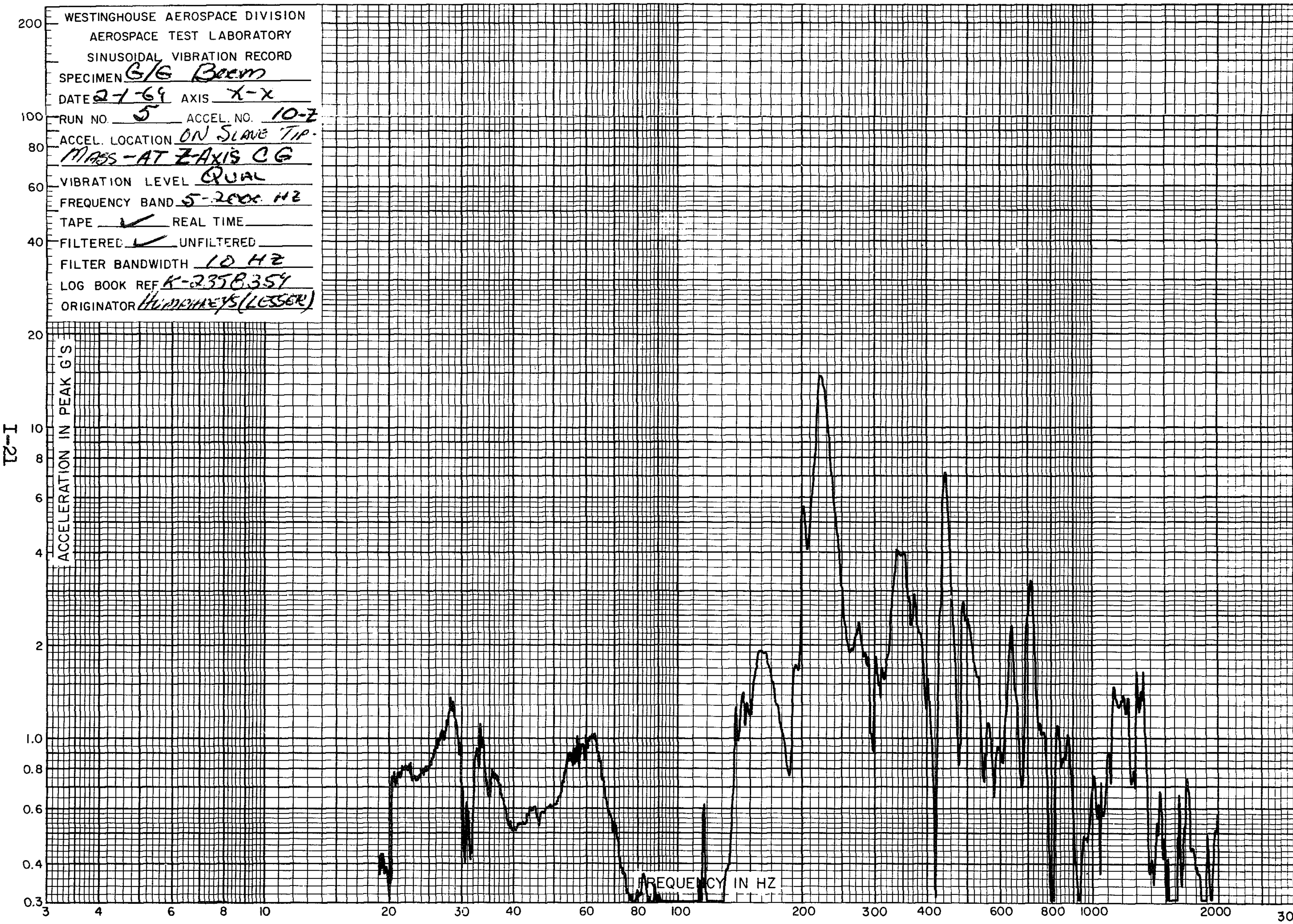
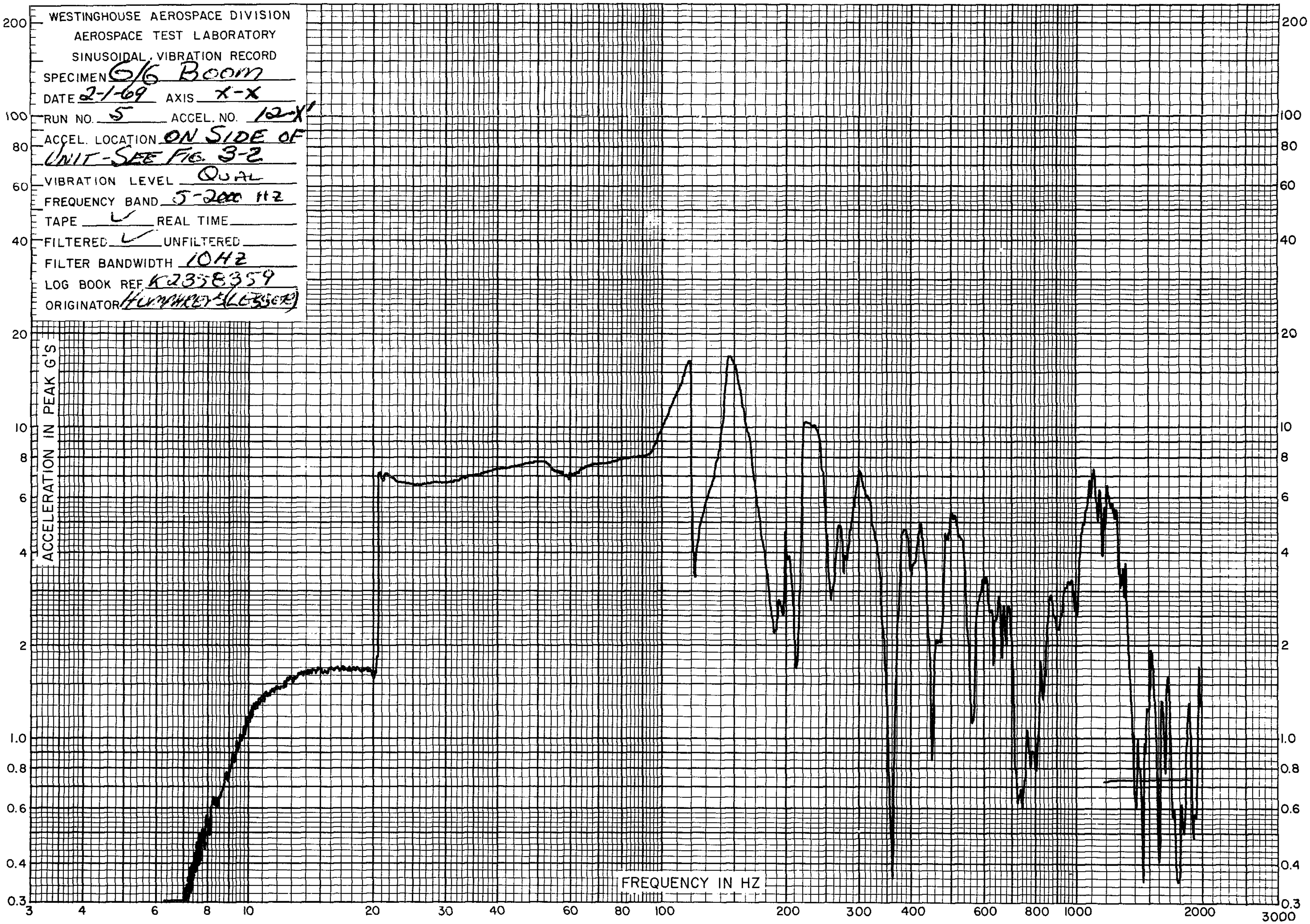

WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1969 AXIS X-X
RUN NO. 5 ACCEL. NO. 9X'
ACCEL. LOCATION ON SIDE OF
UNIT - SEE FIG. 3-2
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF. K-2358359
ORIGINATOR HUMPHREYS (KESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ



WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Beam
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. 10-Z
ACCEL. LOCATION ON SLAVE TIP-
MASS-AT Z-AXIS CG
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358.354
ORIGINATOR HUMPHREYS(LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS X-X
RUN NO. 5 ACCEL. NO. 12-X'
ACCEL. LOCATION ON SIDE OF UNIT-SEE FIG. 3-2
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10HZ
LOG BOOK REF K2358359
ORIGINATOR
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
100
80
60
40
20
10
8
6
4
2
1.0
0.8
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0.4
0.3
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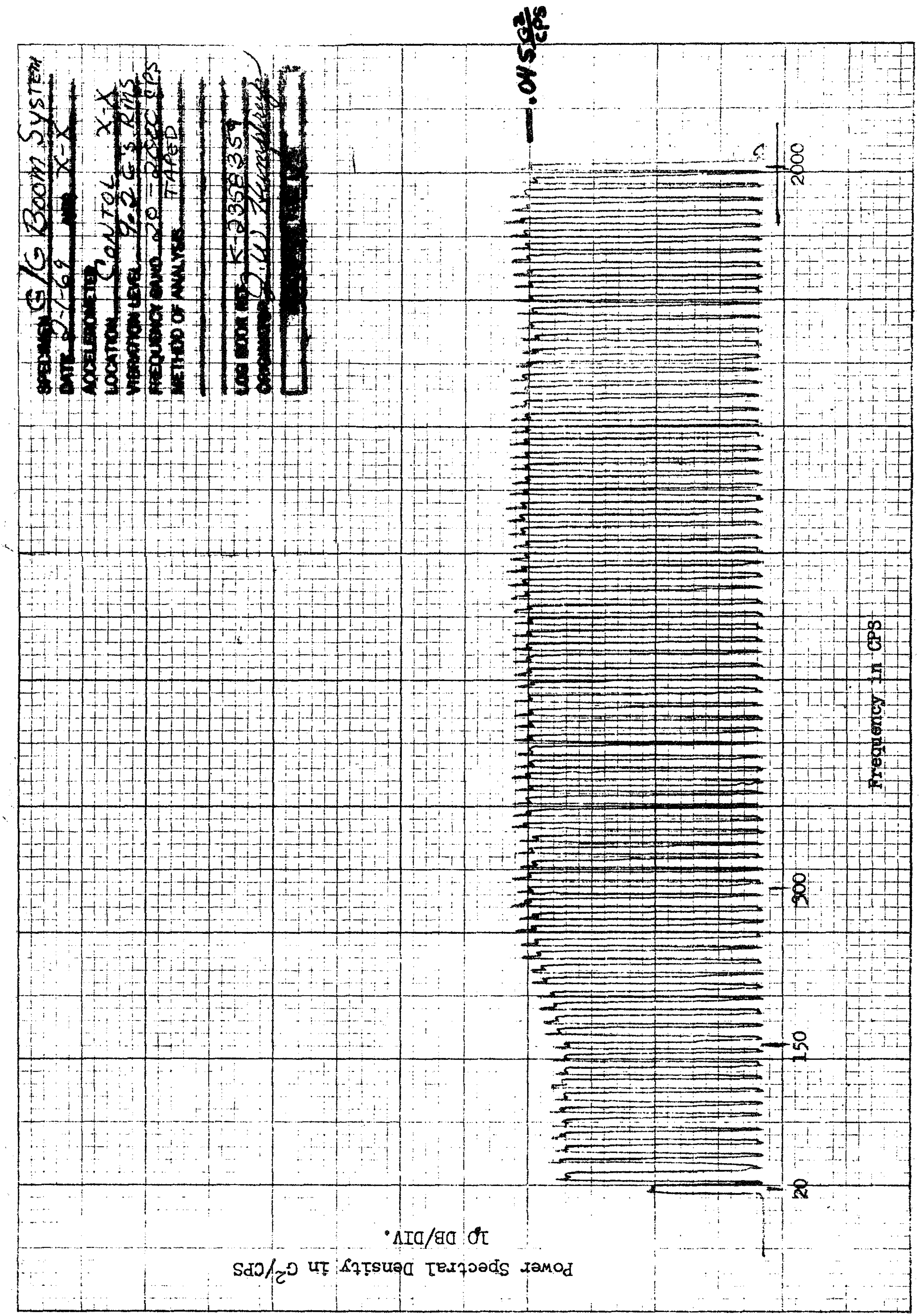
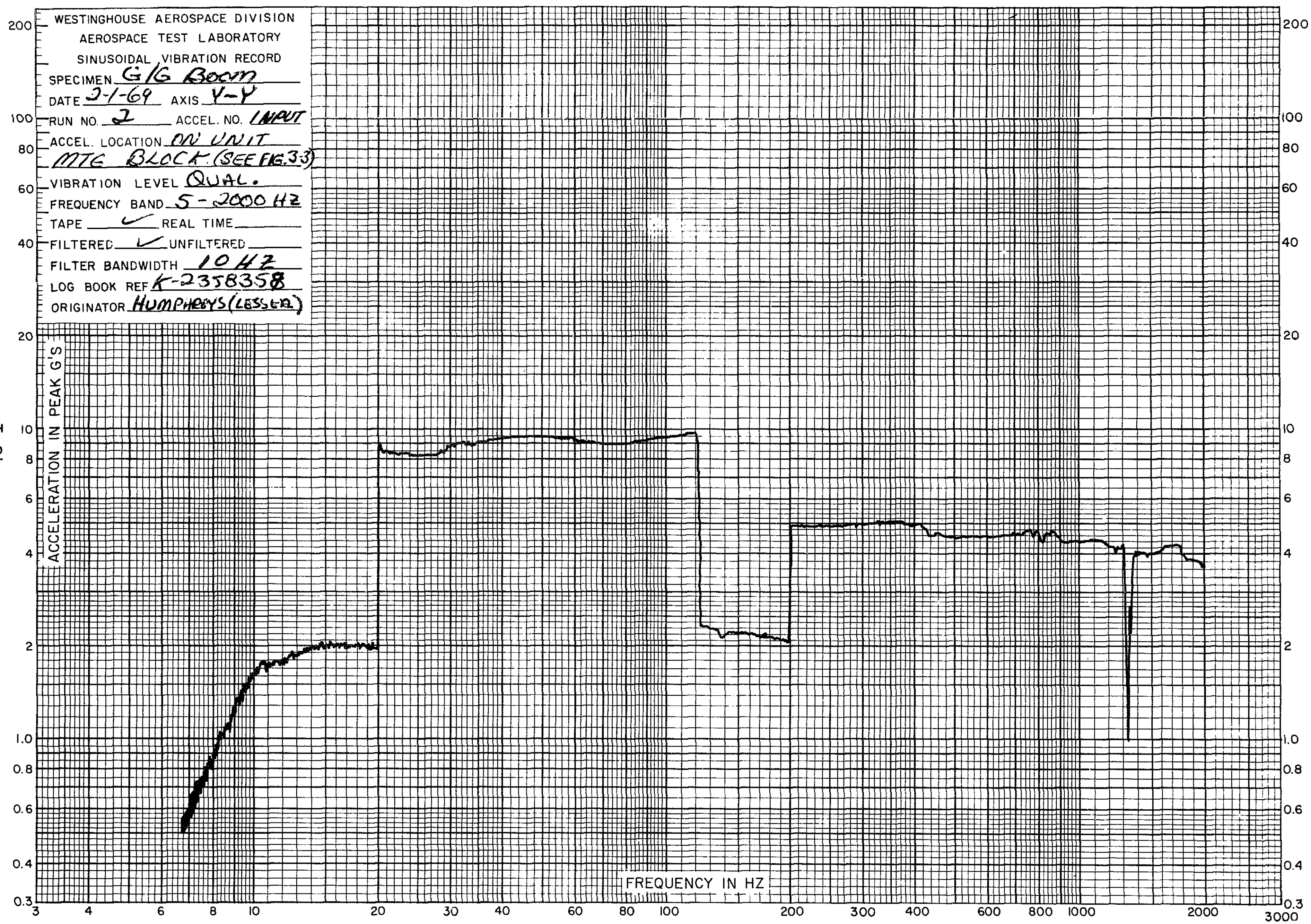
2000
3000



SPECIMEN G/G Boom System
DATE 2-7-69 RUN X-X
ACCELEROMETER
LOCATION Control X-X
VIBRATION LEVEL 9.2 G's RMS
FREQUENCY BAND 20-2000 CPS
METHOD OF ANALYSIS Taped
LOG BOOK REF. K-2358359
OPERATOR G.W. Humphrey
.045 G^2/CPS
2000
300
150
20
Frequency in CPS
Power Spectral Density in G^2/CPS
10 DB/DIV.


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS Y-Y
RUN NO. 2 ACCEL. NO. INPUT
ACCEL. LOCATION ON UNIT
MTG BLOCK (SEE FIG.3.3)
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358358
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
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80
60
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10
8
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0.4
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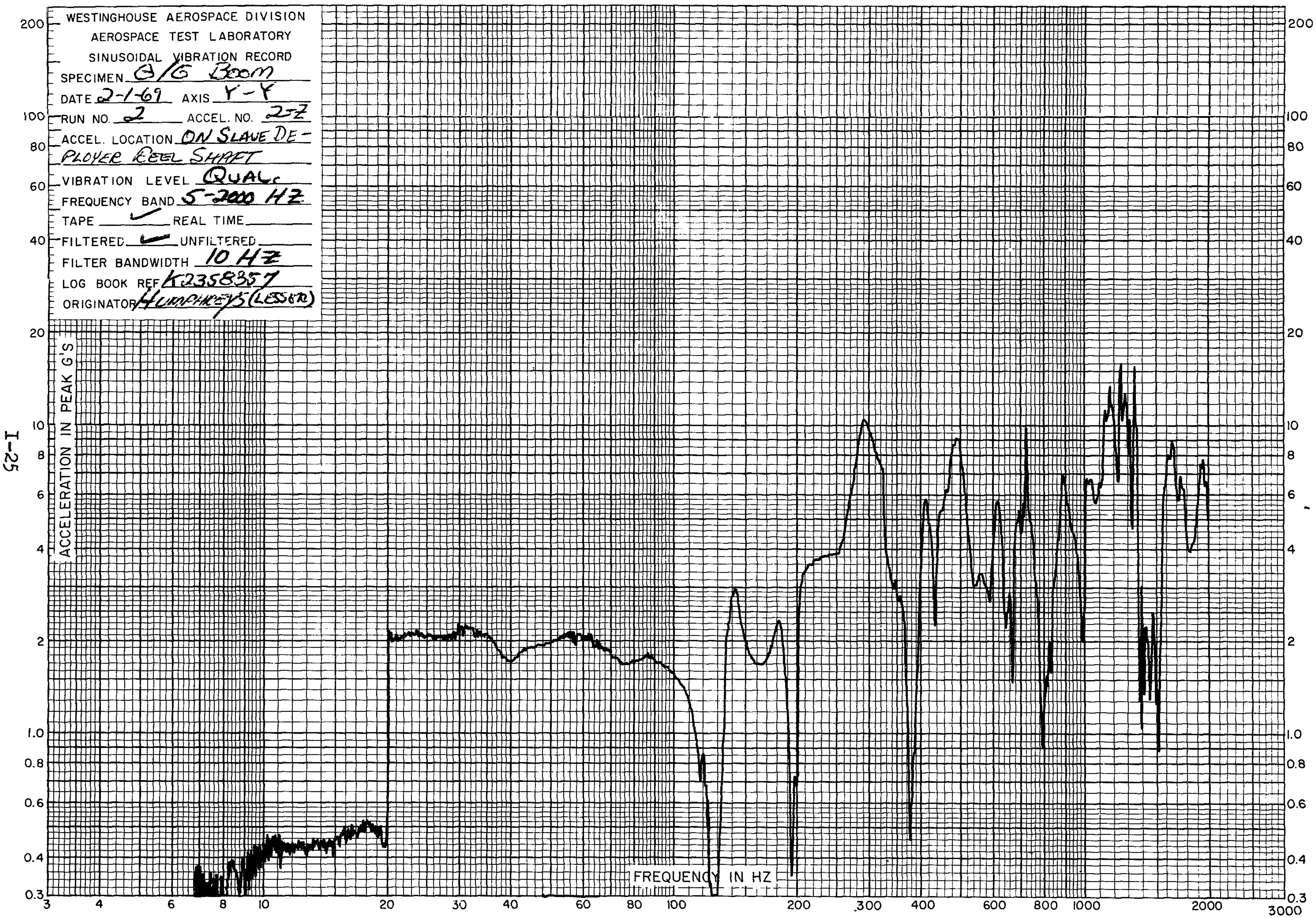
3000



WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS Y-Y
RUN NO. 2 ACCEL. NO. 2-Z
ACCEL. LOCATION ON SLAVE DE-PLOYER REEL SHAFT
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358357
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
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0.4
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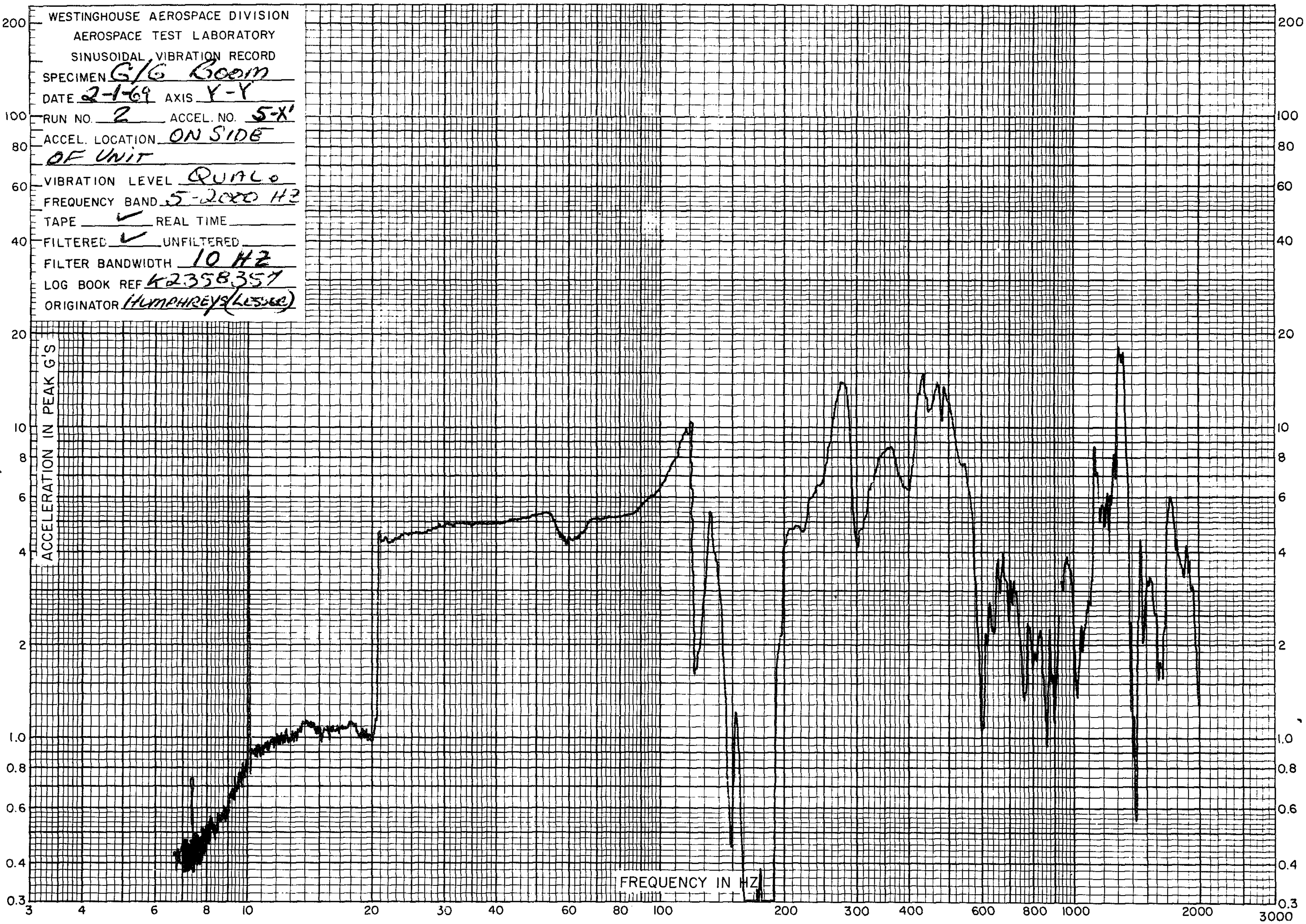
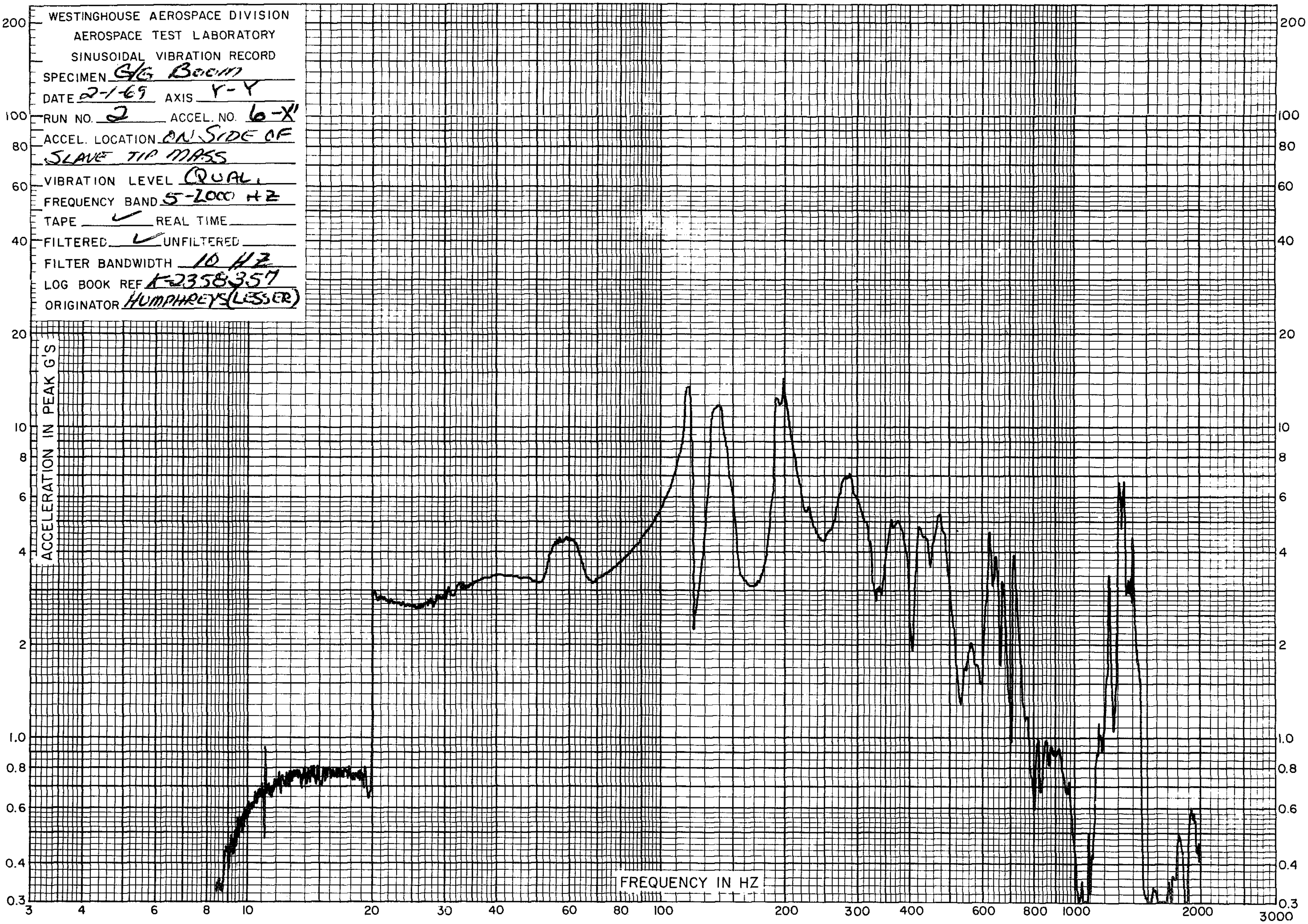
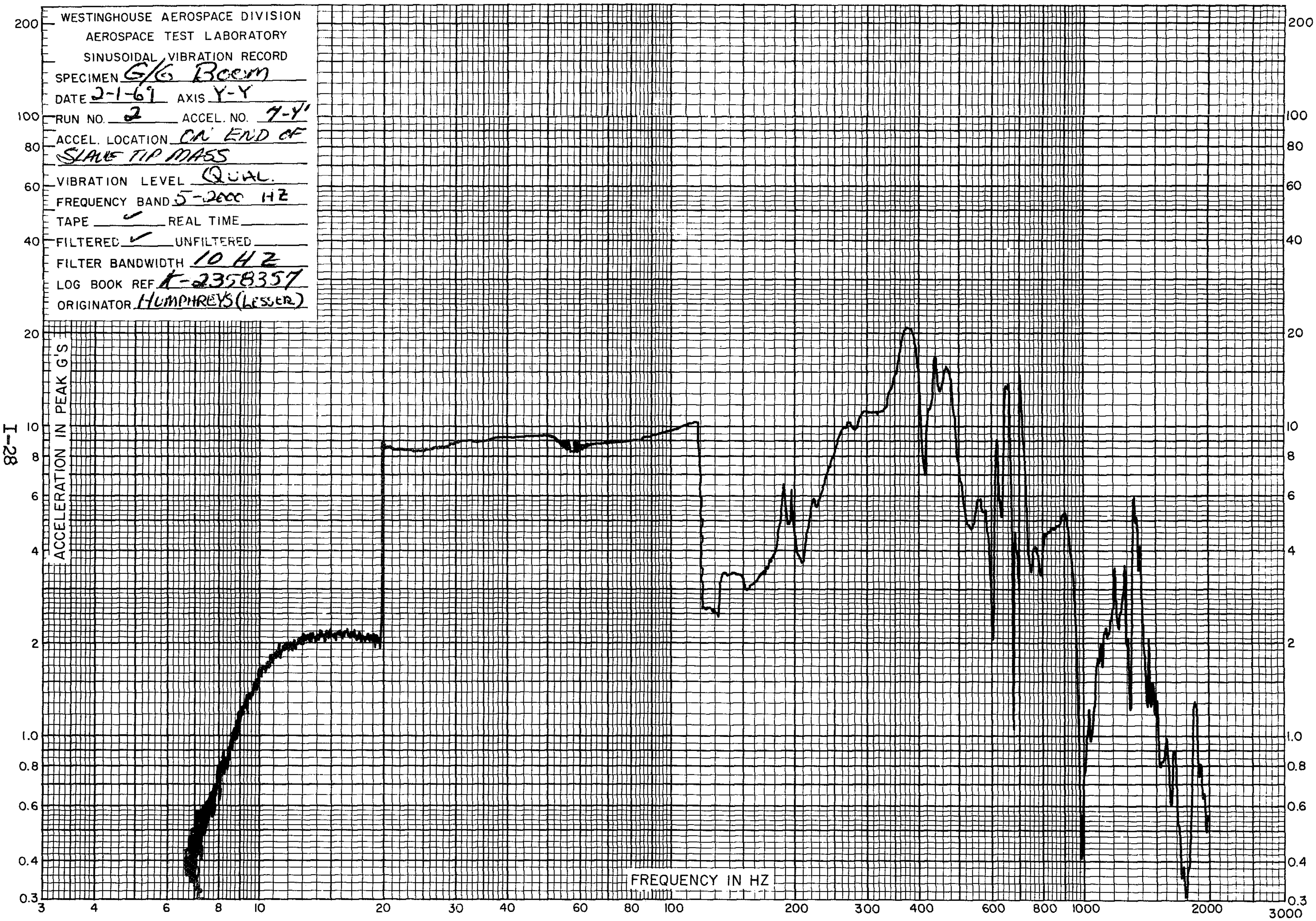
3000

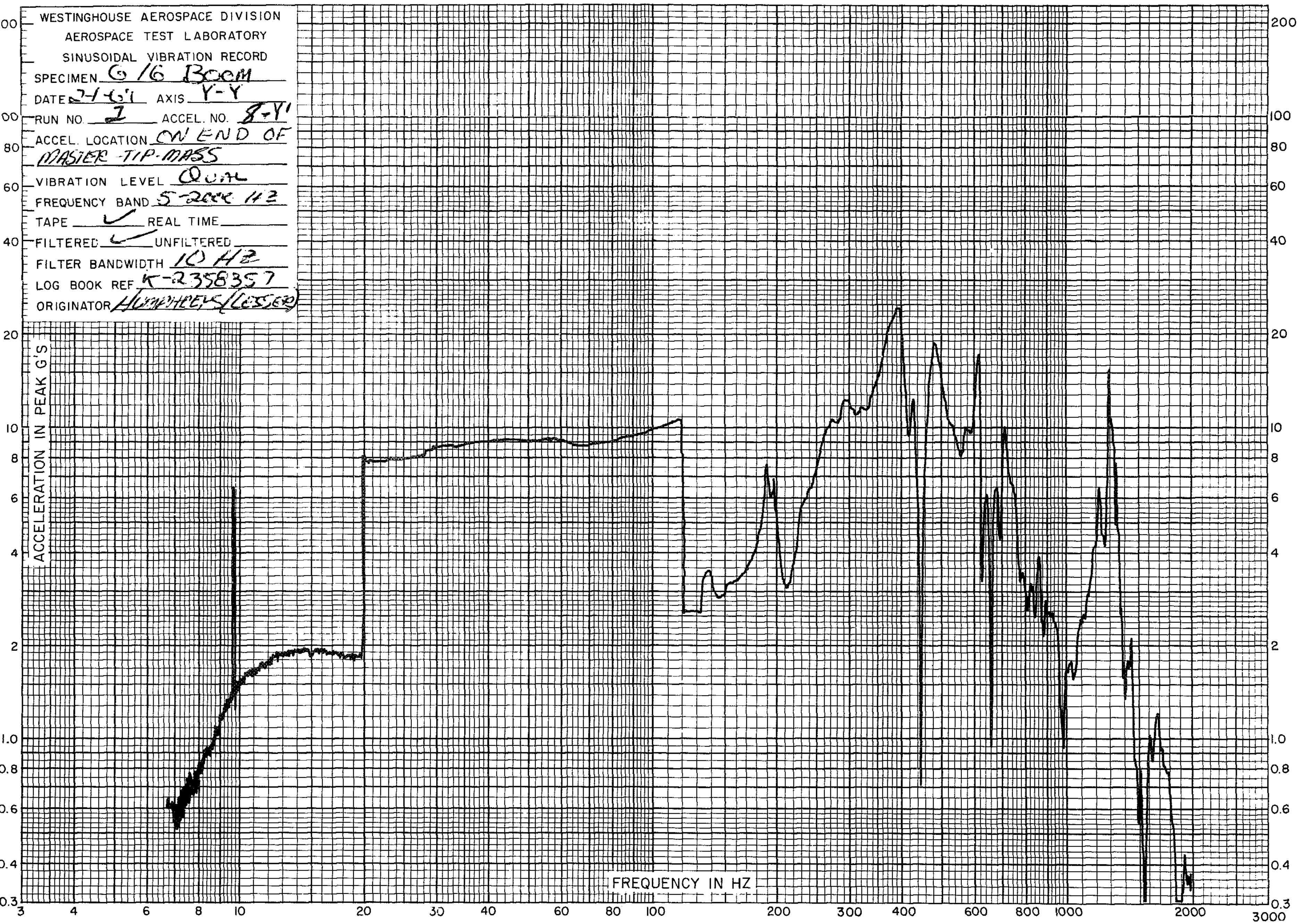


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS Y-Y
RUN NO. 2 ACCEL. NO. 5-X'
ACCEL. LOCATION ON SIDE OF UNIT
VIBRATION LEVEL QUALo
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358,357
ORIGINATOR HUMPHREYS(LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ



WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS Y-Y
RUN NO. 2 ACCEL. NO. 6-X'
ACCEL. LOCATION ON SIDE OF SLAVE TIP MASS
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358357
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS Y-Y
RUN NO. 2 ACCEL. NO. Y-Y'
ACCEL. LOCATION ON END OF SLAVE TIP MASS
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358357
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/6 Boom
DATE 2-4-61 AXIS Y-Y
RUN NO. 1 ACCEL. NO. 8-Y'
ACCEL. LOCATION ON END OF MASTER TIP-MASS
VIBRATION LEVEL Qual
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358357
ORIGINATOR Humphreys (Lesser)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
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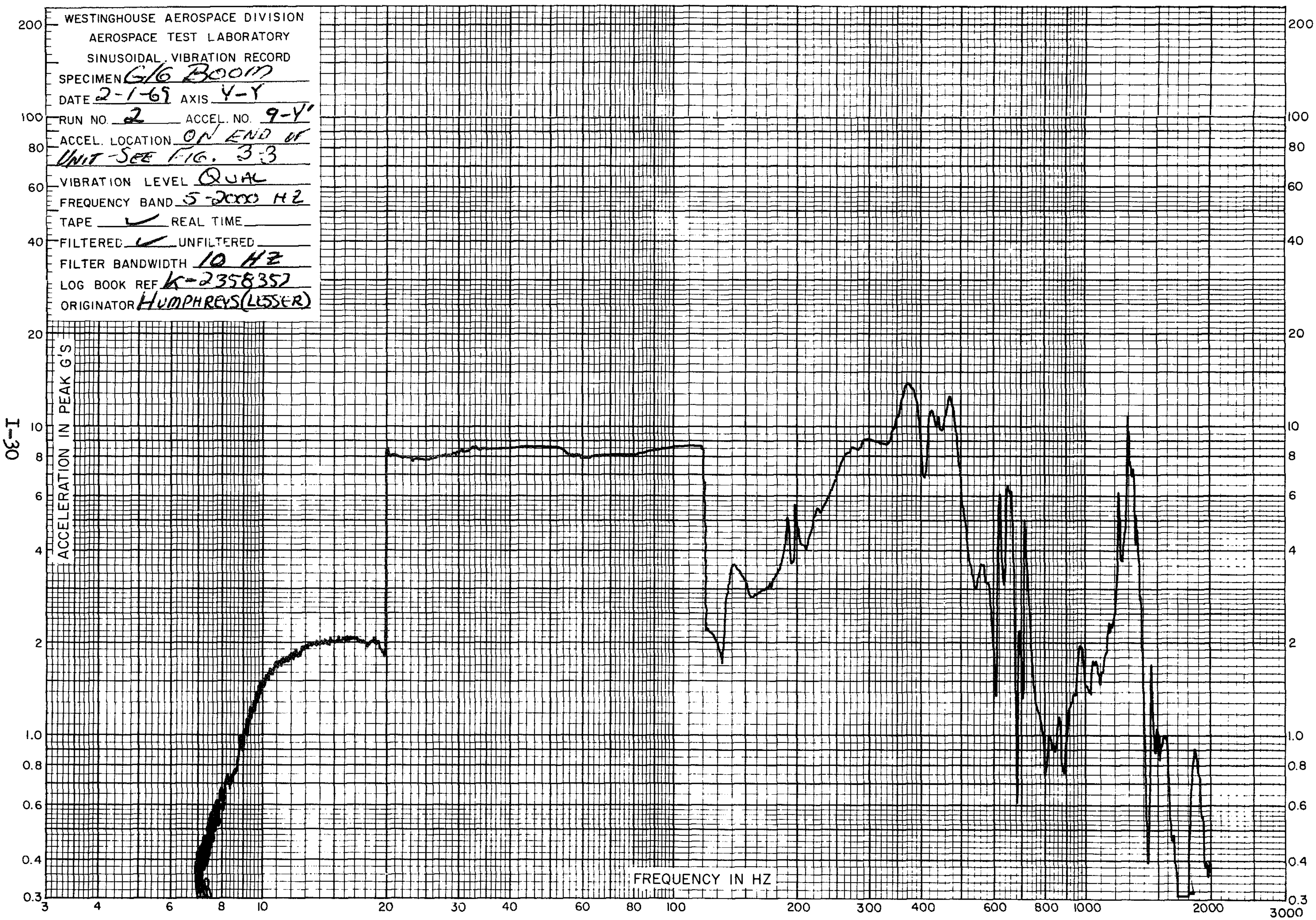
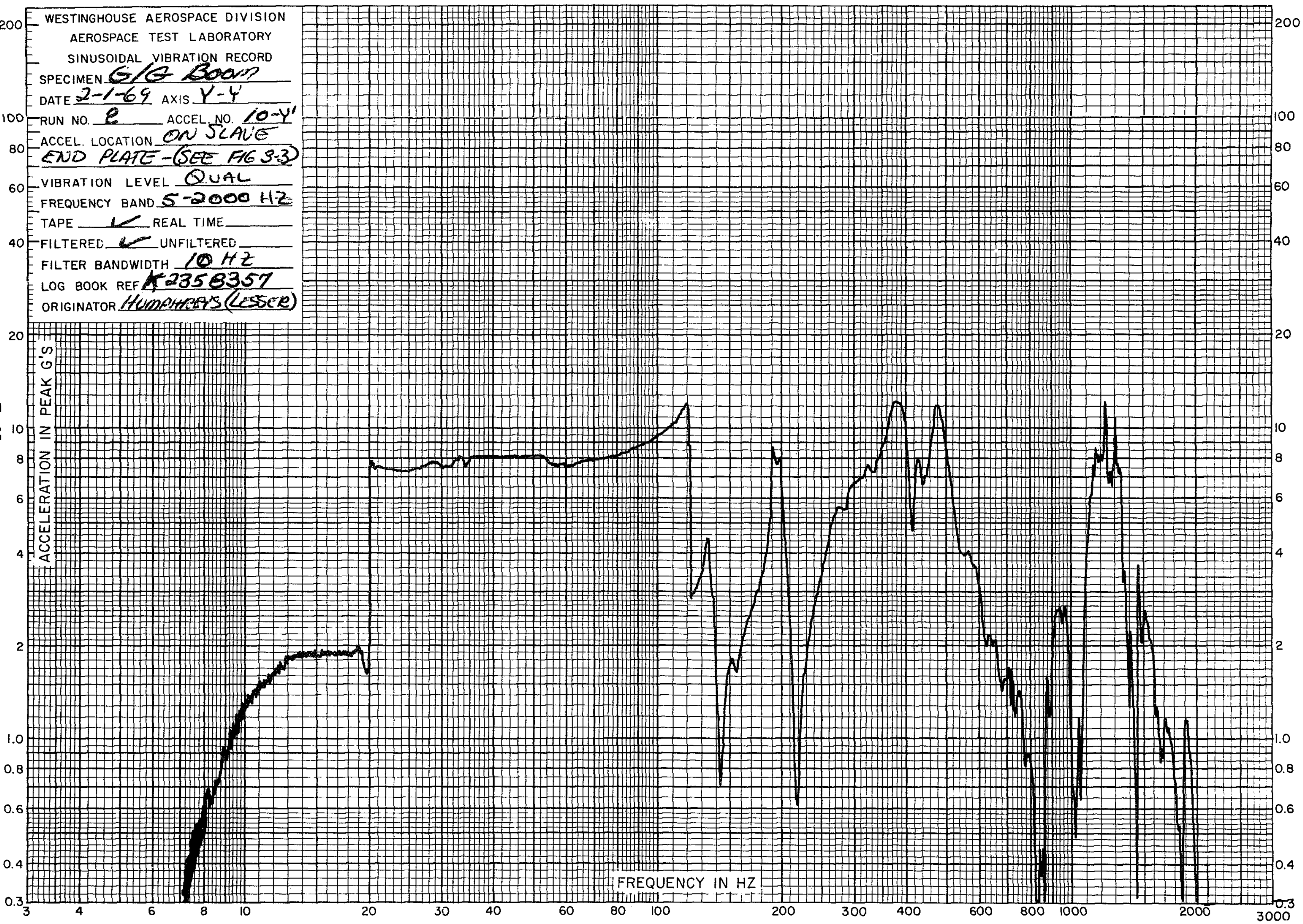

WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G BOOM
DATE 2-1-69 AXIS Y-Y
RUN NO. 2 ACCEL. NO. 9-Y'
ACCEL. LOCATION ON END OF UNIT-SEE FIG. 3-3
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K-2358352
ORIGINATOR HUMPHREYS(LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-69 AXIS Y-Y'
RUN NO. 2 ACCEL. NO. 10-Y'
ACCEL. LOCATION ON SLAVE END PLATE - (SEE FIG 3-3)
VIBRATION LEVEL QUAL
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K2358357
ORIGINATOR HUMPHREYS (LESSER)
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
200
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60
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20
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2
1.0
0.8
0.6
0.4
0.3
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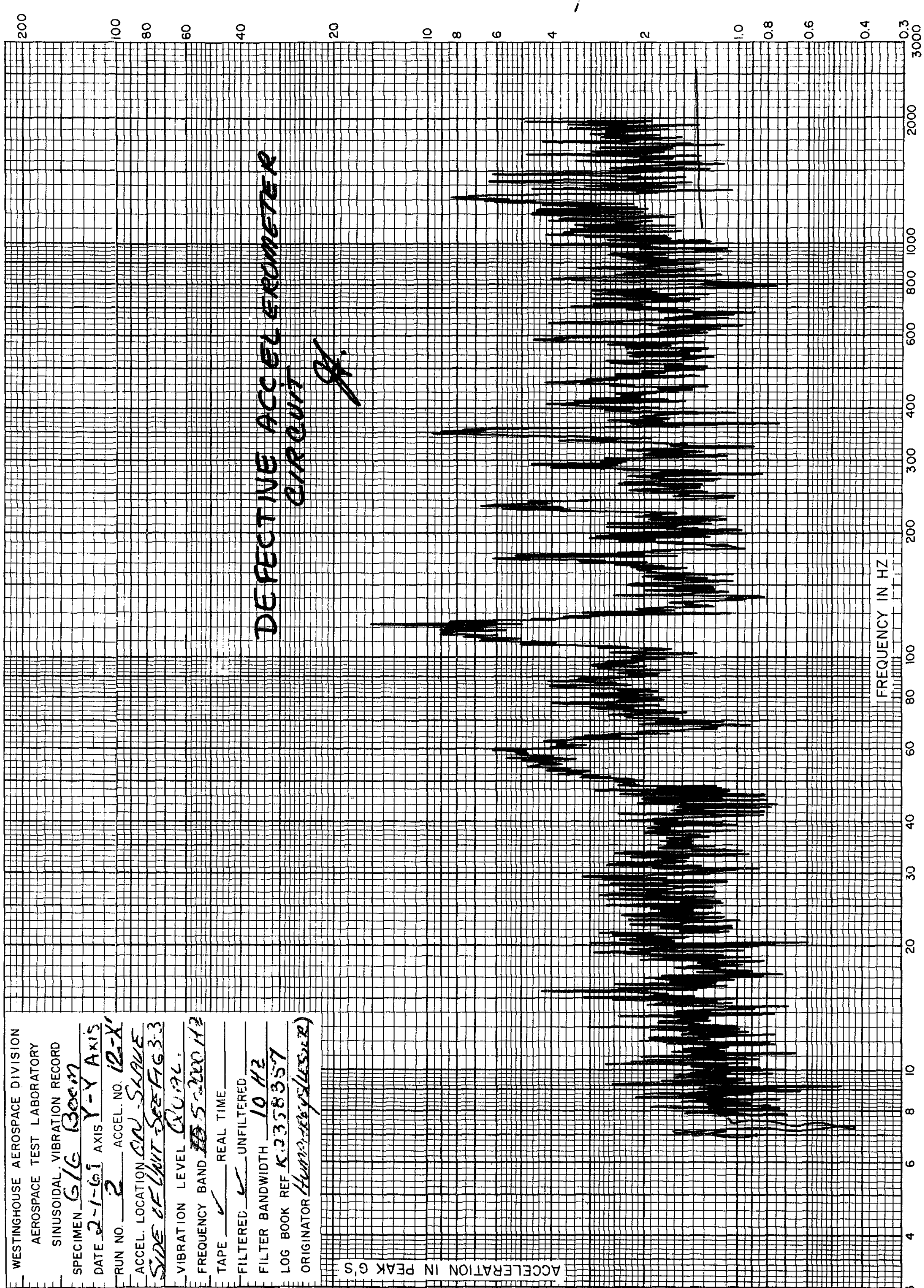
3000


WESTINGHOUSE AEROSPACE DIVISION
AEROSPACE TEST LABORATORY
SINUSOIDAL VIBRATION RECORD
SPECIMEN G/G Boom
DATE 2-1-61 AXIS Y-Y Axis
RUN NO. 2 ACCEL. NO. 12-X'
ACCEL. LOCATION ON SLAVE SIDE OF UNIT SEE FIG 3.3
VIBRATION LEVEL QUAL.
FREQUENCY BAND 5-2000 HZ
TAPE ✓ REAL TIME
FILTERED ✓ UNFILTERED
FILTER BANDWIDTH 10 HZ
LOG BOOK REF K:33583-57
ACCELERATION IN PEAK G'S
FREQUENCY IN HZ
DEFECTIVE ACCELEROMETER CIRCUIT
200
100
80
60
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20
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4
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0.8
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0.4
0.3
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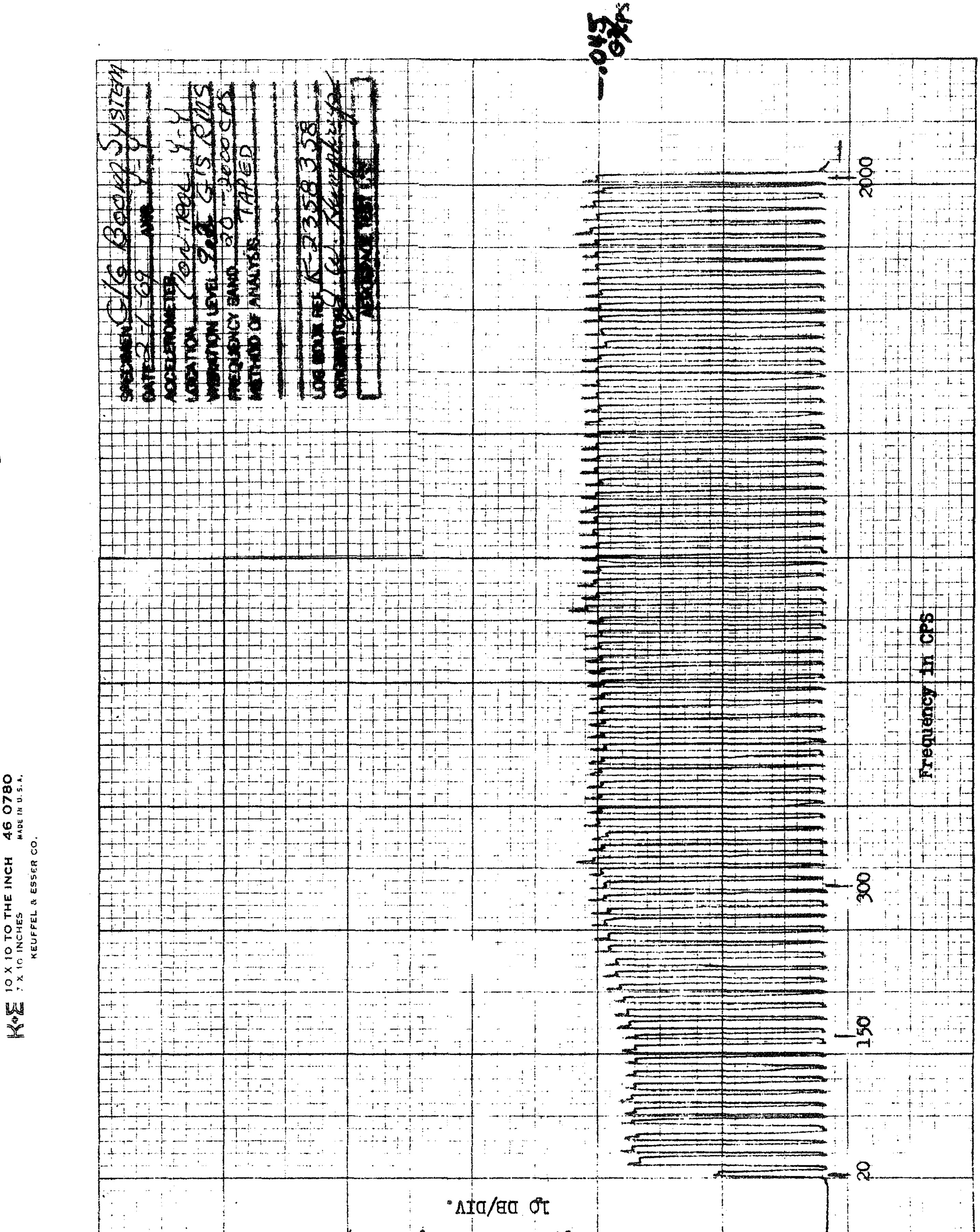
2-1-69



K+E 10 X 10 TO THE INCH 46 0780
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.
SPECIMEN C/G Boom System
DATE 2-1-69
ACCELEROMETER
LOCATION
VIBRATION LEVEL
FREQUENCY BAND 20-2000 CPS
METHOD OF ANALYSIS TAPED
LOG BOOK REF K-22358 3.58
ORIGINATOR
AEROSPACE TEST LAB
.045 G²/cps
20
150
300
2000
Frequency in CPS
Power Spectral Density in G²/CPS
10 DB/DIV.

APPENDIX II

Qualification Test Procedure and Data Sheets

SPECIFICATION NUMBER T789493

REV LTR	DATE	REVISION NOTICE NUMBER	PAGES AFFECTED	APPROVED
B	12-13-68	B5603	1, 2, 18, 23, 25, 26	
A	3-22-67		Pages 1 thru 53	

REVISIONS

ORIGINALLY PREPARED FOR CONTRACT NO. NAS-5-10,285

ORIGINATOR

B S Shephard

R. Wirth

Oct. 29, 1968

Westinghouse Electric Corporation
AEROSPACE DIVISION BALTIMORE, MD., U.S.A.

TITLE

QUALIFICATION TEST PROCEDURE FOR A. T. S. BOOM/DEPLOYER SYSTEM

PAGE 1 OF 53 PAGES	SPECIFICATION TYPE	CODE IDENT. NO.	SPECIFICATION NUMBER
	Append. Pg. II-2	97942	T789493

BA 5856-1

PAGE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
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B																		X					X			X												
C																																						
D																																						
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G																																						
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REVISION LETTER

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A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																							
B																																						
C																																						
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REVISION LETTER

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B																								
C																								
D																								
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REVISION LETTER

DO NOT NUMBER BEYOND 100 IF AN ADDITIONAL INDEX PAGE IS REQUIRED

SPECIFICATION PAGE REVISION INDEX	PAGE	CODE IDENT.	SPECIFICATION NUMBER	REV
II-3	2	97942	T789493	B

1.0 SCOPE

This Qualification Test Procedure shall govern the qualification testing to be performed on the prototype ATS Gravity Gradient Boom System. The tests and inspections contained herein shall be carried out to ensure that the materials, workmanship and performance of the Boom System meet the requirements of NASA Specification S-460-P-1 and contract NAS 5-10285.

2.0 REFERENCE

2.1 Contractual Documents

S-460-P-1	NASA/GSFC Specification for a Gravity Gradient Boom System for Project ATS.
S2-0102	NASA/GSFC Environmental Qualification and Acceptance Test Specification
MIL-STD-202	Test Methods for Electronics and Electrical Component Parts
ATS-ICD-298041	Interface Control Drawing G/G Experiment Primary Stabilization Boom

2.2 Product Documents

662R808	Top Assembly Drawing
613R724	Schematic Diagram (electrical)
662R809	Outline Drawing
ATL-246	Environmental Test Specification
T789490	Test Procedure for Deployer Drive Unit
T789491	Test Procedure for Scissor Mechanism
T789492	Unit Test Procedure
T789495	Boom Straightness Test Specification
PS598213	Deployer Assembly Procedure

3.0 PROCEDURE

3.1 General

Tests shall be performed in the order listed in section 3.2 and all data recorded as required by section 3.3. Specified test voltages shall be ±1% unless otherwise noted.

3.2 Order of Tests

Tests shall be performed in the following order:

Section	Title
5.0	PRE-QUALIFICATION CHECK
5.1	Straightness Test
5.2	Visual and Mechanical Inspection
5.3	Circuit Isolation, D.C. Resistance and Continuity Test
5.4	Insulation Resistance Test
5.5	Dielectric Strength Test
5.6	Electrical Isolation Test
5.7	Leak Test
5.8	Tip Mass Release
5.9	Extension and Retraction Test
5.10	Scissor Test
6.0	HIGH AND LOW TEMPERATURE NON-OPERATIONAL (Combined with Thermal Vacuum)
7.0	HIGH AND LOW TEMPERATURE OPERATIONAL (Combined with Thermal Vacuum)
8.0	HUMIDITY (NO TEST)

Section	Title
9.0	VIBRATION
9.1	Tip Mass Release Test
9.2	Extension and Retraction Test
9.3	Scissor Test
10.0	ACCELERATION
10.1	Extension and Retraction Test
10.2	Scissor Test
11.0	THERMAL VACUUM
11.1	Tip Mass Release Test (Low Temperature - Vacuum)
11.2	Tip Mass Release Test (High Temperature - Vacuum)
11.3	Extension-Retraction and Scissoring Performance (Ambient)
11.4	Extension-Retraction and Scissoring Performance (Low Temperature-Vacuum)
11.5	Extension-Retraction and Scissoring Performance (High Temperature-Vacuum)
12.0	POST-QUALIFICATION CHECK
12.1	Visual Mechanical Inspection
12.2	Insulation Resistance Test
12.3	Dielectric Strength Test
12.4	Electrical Isolation Test
12.5	Tip Mass Release
12.6	Extension and Retraction Test
12.7	Scissor Test
12.8	Leak Test
12.9	Deployer Slip Clutch Torque Test

Section	Title
13.0	Qualification Test Data Sheets

3.3 Test Records

3.3.1 Qualification Test Record

All test data shall be recorded in qualification test record.

3.3.2 Graphs and Calibration Data

All graphs and calibration data for boom length, thermocouples, potentiometer, and motor current shall form a part of the qualification test record.

4.0 TEST EQUIPMENT

4.1 Commercial Test Equipment

The following commercial test equipment or its equivalent shall be used:

Simpson Model 260 Multimeter
EIL Model 29 Megohmmeter Bridge (Megger)
Beta Electric Model 801 Hi-Pot Tester
Tektronix Model 531 Oscilloscope
G.R. Model 1606 A R.F. Bridge
Polaroid Camera
G.R. Type 1212-A Null Detector with 1203 B Power Supply
G.R. Type 1001-A Signal Generator or H.P. 606-A
Schallcross Model 670A Milliohmeter

Digital Recorder H.P. Model H2Y562A

Digital Voltmeter H.P. Model 3440A with automatic Range Section H.P. Model 3442A

Sanborn Recorder Model 150 with (2) AC-DC Preamps and Power Supply

4.2 Special Test Equipment

Test Console

Deployment Test Track   Scissor Angle Fixture

5.0 PRE-QUALIFICATION CHECK

The pre-qualification check consists of those tests (room ambient) and inspections necessary to ensure proper operation of the Boom System. The test data provides a basis for comparison with system performance during and after the environmental qualification test. Data from Unit Test (T789872) may be used in place of testing per Section 5 providing no system alterations or adjustments were made during or after Unit Test.

5.1 Straightness Test

Verify that the two boom elements have undergone the straightness test of specification T789495. Label the recorded data "PRE-QUALIFICATION TEST" and make the data a permanent part of this qualification test record.

5.2 Visual and Mechanical Inspection

5.2.1 Ensure that the unit conforms to Westinghouse Assembly Drawing 662R808G01.

5.2.2 Check and record the envelope dimensions indicated in figures 2 and 3 of the test record and compare to Westinghouse Outline Drawing 662R809 (references ATS-ICD-298041). Nonconformance does not constitute a failure.

5.2.3 Check and record the diameter of the mounting bolt holes.

5.2.4 Check and record the weight of the unit.

5.2.5 Check the inspection record of each Tip Mass Release Mechanism and record the listed weight of each Tip Mass Assembly (Mass, Boom Isolation Assy and associated assembly hardware).

5.2.6 Check the inspection record of the boom elements and note that the adhesion test has been completed.

5.2.7 Check the inspection record for the torque value of each deployer drive unit slip clutch and record. Torque shall be 45 ±5 oz in.

5.3 Circuit Isolation, D.C. Resistance and Continuity Test

5.3.1 Using the multimeter check that there is no circuit between the pins of J1 as listed on the check list in test record. Record as a checkmark.

5.3.2 Using the multimeter check the D.C. resistance or continuity between pins of J1 as listed on the check list in test record. Record as a checkmark.

5.4 Insulation Resistance Test

5.4.1 Using the 100 volt megger where indicated in test record, check that the insulation resistance between the circuits of the output connector J1 and the structure is not less than 10 megohms at 100 VDC. Record as a checkmark.

5.4.2 Using the 200 volt megger apply 200 volts between pin and structure for pins A1 and A2 of the RF connector J2. Check that the insulation resistance is not less than 50 megohms and record as a checkmark.

5.5 Dielectric Strength Test

5.5.1 Using the hi-pot tester apply 100VAC 60 Hz, where indicated in test record, for one second between the circuits of the output connector J1 and the structure. There shall be no breakdown. Record as a checkmark.

5.5.2 Using the hi-pot tester apply 200VAC 60 Hz, for one second between pin and structure for pins A1 and A2 of the RF connector J2. There shall be no breakdown. Record as a checkmark.

5.6 Electrical Isolation Test

5.6.1 Using the megohms bridge measure the resistance between the two primary boom elements and between each element and the structure (Measure between pins A1 and A2 of the RF connector J2 and between each pin and the structures.) Each resistance shall be 100 megohms or greater. Record.

5.6.2 Using the RF bridge, null detector and standard signal generator measure the capacitance at 250 kHz and 2.5 MHz between the two primary boom elements and between each boom element and the structure. The capacitance in each instance shall be less than 200 picofarads. Record

5.6.3 Using the milliohmmeter, check the resistance between pin A1 of the RF connector J2 and A2 deployer boom element, and between pin A2 of the RF connector J2 and A3 deployer boom element. The maximum contact resistance shall be 0.100 ohms. Record.

5.7 Leak Test

5.7.1 Check that the scissor mechanism and each motor housing has been pressurized, sealed and leak tested as individual sub-assemblies. The atmosphere shall be a mixture of helium and moist air per T789491 and T789490 for the scissor mechanism and motor housing, respectively. The pressure shall be 7.5 ± 1 psia and 15.0 ± 1 psia respectively. Record.

5.7.2 Using the heilum leak detector, perform the leak test of paragraph 4.2 of Environmental Test Specification ATL-246 for a total time of 4 hours. Leak rate shall be less than 3×10^{-6} std. cc/sec.

Calculate and record total leak rate based on measurement.

5.8 Tip Mass Release Test

5.8.1 Place UNDER each tip mass a supporting fixture which will permit the masses to move 3 to 4 inches without loading the boom elements when the tip masses release.

5.8.2 Ensure that all switches on the test console are in the "OFF" position.

5.8.3 Attach the test console to the Boom System through connector J1.

5.8.4 Place the power plugs in "BOOMS".

5.8.5 Turn power supply "ON" and set voltage to 22 VDC.

CAUTION

DO NOT APPLY POWER TO THE CABLE CUTTERS.

5.8.6 Using a suitable cutting tool, cut the cable of each tip mass release mechanism near each cable cutter. Do not remove the cables.

5.8.7 Complete the tip mass release by placing "momentary" power switch in the "EXTEND" position a sufficient number of times to determine that both tip masses have been released. (Do not extend more than 3 to 4 inches). Record.

CAUTION

Use extreme caution in this operation to prevent damage to the boom elements.

5.8.8 Turn power supply "OFF".

5.8.9 Remove Tip Masses (515R225G01 and 515R258G01) and Boom Isolation Assys (418R439G01) from the boom system.

5.9 Extension and Retraction Test

CAUTION

Do NOT perform this test unless the environment surrounding the system has a relative humidity less than 85%.

5.9.1 Make certain that both Tip Mass Assemblies have been removed from the system.

5.9.2 Ensure that all switches on the test console are in the "OFF" position, that the console is set for "BOOMS" and that the test console and Boom System are connected through J1.

5.9.3 Turn power supply "ON" and set voltage at 22 VDC.

5.9.4 "EXTEND" the boom elements approximately 3 feet.

5.9.5 Attach the master deployer boom to the Test Track Trolley using the tip plug adapter and attach the slave deployer boom to the leader tape of the Take-Up Mechanism. (Boom-to-tape connection is a temporary splice accomplished with a .002 inch maximum thick single sided sticky tape.)

5.9.6 During the extension-retraction test, the following information shall be recorded by means of the Sanborn recorder and digital voltmeter:

(1) Output of the Test Track Reed Switches.

(2) One second time intervals.

(3) Output of the extension read-out potentiometer for the boom element attached to the Test Track Trolley.

(4) Current to the Boom System.

(5) Starting current spikes and transients shall be photographed.

5.9.7 Current to the Boom System shall be monitored.

5.9.8 Check that voltage is 22 VDC.

5.9.9 "EXTEND" the booms.

CAUTION

To prevent damage to the boom elements during extension or retraction, power from the test console must be supplied simultaneously to the Boom System and to the Take-Up Mechanism. The Take-Up Mechanism should be maintained at approximately mid-position on its track, by controlling the motor speed. Motor speed is controlled automatically or by manually adjusting the supply voltage. Limit switches at each end of the take-up mechanism track will shut down the system if tripped by the take-up mechanism during manual operation.

5.9.10 When both elements reach full extension, they will individually activate their respective limit switches and stop. The "MASTER" and "SLAVE" limit switch lights shall come "ON". Record as a check mark on data sheet. On the boom deployed down the track, place a thin circumferential ink mark on the boom at a point 48 ±1/32 inch from the outer end of the deployer Guide Support (515R193G01). Record limit switch reference mark location on data sheet.

5.9.11 Retain the recorder charts for inspection records and record the following information on the data sheet:

(1) Extended length of element.

(2) O.D. of the element measured every 25 feet.

CAUTION

Be careful not to damage boom section during measurement.

(3) Average rate of extension.

(4) Maximum boom system current.

5.9.12 At this time, the extended length as measured from the pivot point of the individual deployer to the end of the boom element shall be greater than 130 feet.

5.9.13 The O.D. of the element shall be 0.500 ±0.020 inches.

5.9.14 The average rate of extension shall be 0.6 ±0.15 ft/sec.

5.9.15 Ensure that the element has not been damaged by deployment.

5.9.16 "RETURN" the booms until approximately 3 feet of element is still extended. "MASTER" and "SLAVE" limit switch lights shall go "OFF". Record.

CAUTION

There are no limit switches for retraction, and power to the deployer motors is not automatically turned "OFF".

5.9.17 During retraction the same information shall be recorded as per 5.9.6, 5.9.11 (3) and 5.9.11 (4). The average rate of retraction shall be 0.6 ±0.15 ft/sec.

5.9.18 Repeat 5.9.4 through 5.9.17 with the power supply voltage at 30 VDC. Maximum system current shall be 1.00 amp. The limit switch reference mark shall be located 48 ±2.5 inch from the deployer as defined in 5.9.10.

5.9.19 Remove Test Track Trolley from master deployer boom and remove Take-Up Mechanism and leader tape from the slave deployer boom.

CAUTION

Extreme care must be exercised in 5.9.19. Do not damage boom elements.

5.9.20 Reduce power supply voltage to 22 VDC.

5.9.21 "RETURN" booms until approximately 3 inches of element is still extended. Deployer may be operated by tool through access hole.

5.9.22 Turn power supply "OFF".

5.9.23 Reverse the position of the Boom System so that the boom element previously stored on the Take-Up Mechanism may be deployed and repeat 5.9.1 through 5.9.17, 5.9.19, and 5.9.20.

5.9.24 "RETURN" booms completely. (See 5.9.21)

5.9.25 Turn power supply "OFF".

5.10 Scissor Test

5.10.1 Ensure that all switches on the test console are in the "OFF" position, that the test console is set for "SCISSOR", and that the test console and Boom System are connected through J1.

5.10.2 Using the Scissor Angle Fixture, measure each acute angle formed by the centerline of a boom element and the centerline through a pivot point of each deployer (see figure 1). Record. The recorded latching angle shall be 18.3 ±0.5 deg. (If necessary, turn power supply "ON", adjust latching angle, and turn power supply "OFF".

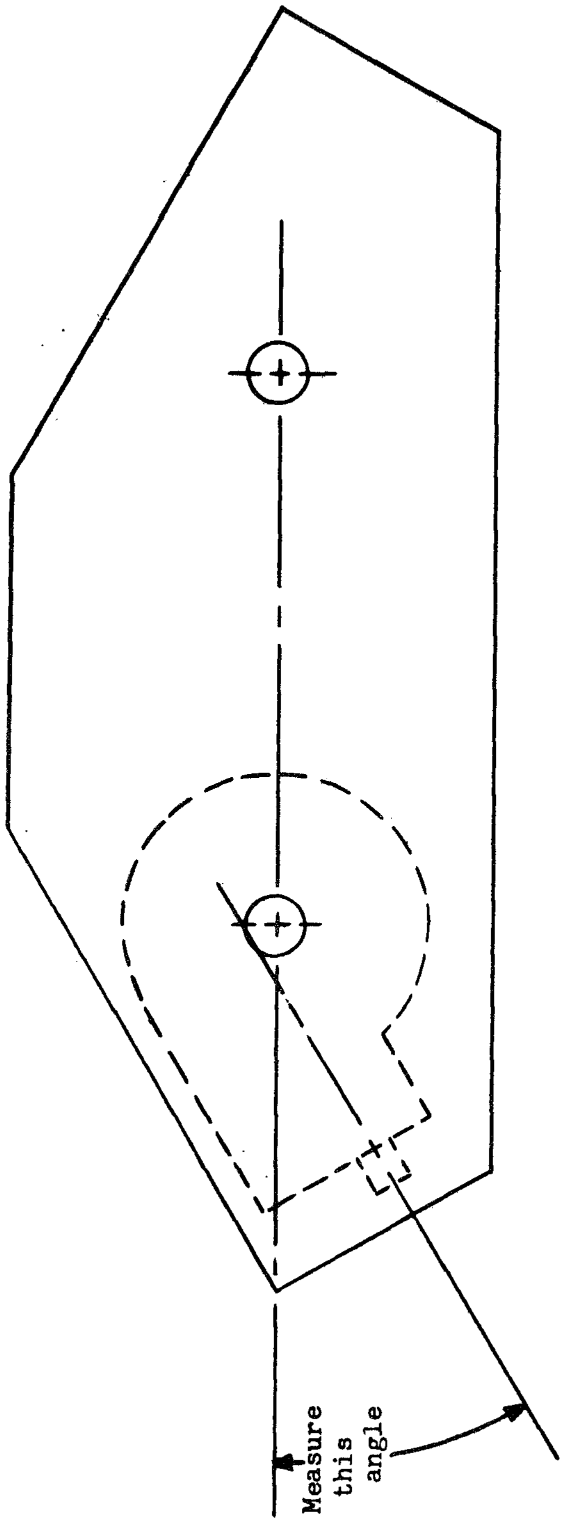

Figure 1

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5.10.3 Measure the scissor potentiometer "wiper to ground" resistance or voltage and the resistance or voltage across the potentiometer. Record these values as a ratio (ratio $\leq$ 1.0) $\frac{\text{wiper to Ground}}{\text{across potentiometer}}$

5.10.4 Turn power supply "ON" and set voltage at 22 VDC.

5.10.5 Scissor the deployers to their maximum angle limit switches, by placing power switch in the "INCREASE" position. "MAXIMUM" angle limit switch light shall come "ON". Record.

5.10.6 During the scissor test, the following information shall be recorded by the Sanborn recorder, digital voltmeter and resistance and capacitance measuring equipment:

(1) Scissor motor current.

(2) Scissor potentiometer voltages.

(3) One second time intervals.

(4) Resistance and capacitance measurements at maximum and minimum angles.

(5) Photograph starting current spikes and transients.

5.10.7 Measure the acute angle of each deployer boom element centerline as defined in paragraph 5.10.2 (see figure 1) and record. The recorded maximum angle shall be 28.0 ±0.5 deg.

5.10.8 Record the scissor potentiometer ratio for this angle (see 5.10.3).

5.10.9 Repeat 5.6.1 and 5.6.2.

5.10.10 Scissor the deployers to their minimum angle limit switches, by placing power switch in the "DECREASE" position. "MINIMUM" angle limit switch light shall come "ON". Record with checkmark.

5.10.11 Repeat 5.10.6 through 5.10.9 for the minimum angle. The recorded minimum angle shall be 13.0 ±0.5 deg.

5.10.12 Using the continuously recorded data of 5.10.10, the maximum and minimum angles from 5.10.7 and 5.10.11 calculate the average scissor rate. Record. Rate shall be 1/8 ±1/16 deg/sec.

5.10.13 Record maximum motor current.

5.10.14 Scissor the deployers to the maximum angle. "MAXIMUM" angle limit switch light shall come "ON". Record with checkmark.

5.10.15 Calculate the average scissor rate using angle data from 5.10.7, and 5.10.11, and continuously recorded data from 5.10.14. Record. Record maximum motor current.

5.10.16 Set power supply voltage at 30VDC. Max. motor current to be 0.66 amps.

5.10.17 Repeat 5.10.10, 5.10.12, 5.10.13, 5.10.14 and 5.10.15.

5.10.18 Set power supply voltage at 22 VDC.

5.10.19 Scissor deployers to the latching angle as measured in 5.10.3. Repeat 5.10.2 and 5.10.3 and record.

5.10.20 Turn power supply "OFF".

6.0 HIGH AND LOW TEMPERATURE NON-OPERATIONAL

This test has been combined with the Thermal Vacuum tests of 11.0 and will not be performed separately.

7.0 HIGH AND LOW TEMPERATURE OPERATIONAL

This test has been combined with the Thermal Vacuum tests of 11.0 and will not be performed separately.

8.0 HUMIDITY (THIS TEST NOT TO BE PERFORMED)

9.0 VIBRATION

CAUTION

Do not perform this test unless the environment surrounding the system has a relative humidity less than 85%.

The vibration test contained in paragraphs 4.4 of Environmental Test Specification ATL0246 shall be performed on the Boom System. No operational or performance tests shall be conducted during this test. The System shall be in a non-operational condition with no voltages applied throughout this environmental test. The tests of 9.1 and 9.2 shall be performed at the conclusion of this environmental test to ensure successful completion of the vibration test.

Before beginning the vibration test, Boom Isolation Assembly (418R439G01) of the Tip Mass Assembly shall be soldered to each boom element - per assembly drawing 662R808 and the tip masses (515R225G01 and 515R258G01) shall be attached per assembly drawings 613R771 and 613R772. Add the tip target standoffs and tip target simulated weights to the tip masses . At the conclusion o of the vibration test, perform the test of 9.1 but do not fire cable cutters. After the test of 9.1 and before the tests of 9.2 and 9.3 the Tip Mass Assemblies shall be re-moved without firing the cable cutters.

CAUTION

DO NOT APPLY POWER TO THE CABLE CUTTERS

9.1 Tip Mass Release Test

9.1.1 Repeat 5.8.

9.2 Extension and retraction Test (Room Ambient)

CAUTION

Do NOT perform this test unless the envrionment surrounding the system has a relative humidity less than 85%.

9.2.1 Ensure that the Tip Mass Assembly has been removed from both boom elements.

9.2.2 Ensure that all switches on the test console are in the "OFF" position, that the console is set for "BOOMS", and that the test console and Boom system are connected through connector J1.

9.2.3 Turn power supply "ON" and set voltage at 22 VDC.

9.2.4 "EXTEND" the boom elements approximately 3 feet.

9.2.5 Attach the master deployer boom to the Test Track Trolley using the tip plug adapter and attach the slave deployer boom to the leader tape of the Take-Up Mechanism. (Boom-to-tape connection is a temporary splice accomplished with a .002 inch maximum thick single sided sticky tape.)

9.2.6 During the extension-retraction test, the following information shall be recorded by means of the Sanborn recorder and digital voltmeter.

(1) Output of the Test Track Reed Switches.

(2) One second time intervals.

(3) Output of the extension read-out potentiometer for the boom element attached to the Test Track Trolley.

(4) Current to the Boom System.

(5) Photograph starting current spikes and transients.

9.2.7 Current to the Boom System shall be monitored and the maximum value recorded.

9.2.8 Check that voltage is 22 VDC.

9.2.9 "EXTEND" the booms.

CAUTION

To prevent damage to the boom elements during extension or retraction, power from the test console must be supplied simultaneously to the Boom System and to the Take-Up Mechanism. The Take-Up Mechanism should be maintained at approximately mid-position on its track by controlling the motor speed. Motor speed is controlled automatically or by manually adjusting the supply voltage. Limit switches at each end of the take-up mechanism track will shut down the system if tripped by the take-up mechanism during manual operation.

9.2.10 When both elements reach full extension, they will individually activate their respective limit switches and stop. "MASTER" and "SLAVE" limit switch lights shall come "ON". Record as a check mark on data sheet.

9.2.11 Retain the recorder charts for inspection records and record the following:

(1) Extended length of element.

(2) Average rate of extension.

(3) Maximum boom system current.

9.2.12 At this time, the extended length as measured from the pivot point of the master deployer to the end of the boom element shall be greater than 130 feet.

9.2.13 The rate of extension shall be 0.60 ±0.15 ft/sec.

9.2.14 "RETURN" the boom until approximately 3 feet of element is still extended. "MASTER" and "SLAVE" limit switches shall go "OFF". Record.

CAUTION

There are no limit switches for retraction, and power to the deployer motors is not automatically turned "OFF".

9.2.15 During retraction the same information shall be recorded per 9.2.6. and 9.2.11. The rate of retraction shall be 0.60 ±0.15 ft/sec.

9.2.16 Remove Test Track Trolley and Take-Up Mechanisms from boom elements.

9.2.17 "RETURN" booms completely.

9.2.18 Turn power supply "OFF".

9.3 Scissor Test (Room Ambient)

9.3.1 Ensure that all switches on the test console are in the "OFF" position, that the test console is set for "SCISSOR", and that the test console and Boom System are connected through J1.

9.3.2 Repeat 5.10.2. The recorded latching angle shall be within 0.5 deg of the first value recorded in 13.2.10 (test of 5.10).

9.3.3 Determine the latching angle scissor potentiometer ratio (See 5.10.3) and record.

9.3.4 Turn power supply "ON" and set voltage at 22 VDC.

9.3.5 Scissor the deployers to their maximum angle limit switches, by placing power switch in the "INCREASE" position. "MAXIMUM" angle limit switch light shall come "ON". Record.

9.3.6 During the scissor test, the following information shall be recorded by means of the Sanborn recorder and digital voltmeter:

(1) Scissor motor current.

(2) Scissor potentiometer voltages.

(3) One second time intervals.

(4) Photograph starting current spikes and transients.

9.3.7 Record the scissor potentiometer ratio. (See 5.10.3).

9.3.8 Scissor the deployers to their minimum angle limit switches, by placing power switch in the "DECREASE" position. "MINIMUM" angle limit switch light shall come "ON". Record.

9.3.9 Record the scissor potentiometer ratio. (See 5.10.3)

9.3.10 Scissor the deployers to their maximum angle limit switches by placing power switch in the "INCREASE" position. "MAXIMUM" angle light shall come "ON". Record.

9.3.11 Record the scissor potentiometer ratio. (See 5.10.3)

9.3.12 Scissor the deployers to the latching angle as determined by the scissor potentiometer ratio recorded in 6.2.2. Record.

9.3.13 Turn power supply "OFF".

9.3.14 Using the data of 9.3.5, 9.3.6, 9.3.8, and 9.3.10, calculate the average scissor rates. Record. Rate shall be 1/8 ±1/16 deg/sec.

10.0 ACCELERATION

The acceleration test contained in paragraph 4.5 of Environmental Test Specification ATL0246 shall be performed on the Boom System. No operational or performance tests shall be conducted during this test. The System shall be in a non-operational condition with no voltages applied throughout this environmental test. The tests of 10.1 and 10.2 shall be performed at the conclusion of this environmental test to ensure the capability of the boom half system to withstand acceleration.

Before beginning the acceleration test, tip masses (515R225G01 and 515R258G01) shall be attached per assembly drawing 662R808. Boom isolation assembly (418R439G01) need not be soldered to the boom elements. At the conclusion of the acceleration test and before the tests of 10.1 and 10.2 the Tip Mass Assemblies shall be removed without firing the cable cutters.

CAUTION

DO NOT APPLY POWER TO THE CABLE CUTTERS.

10.1 Extension and Retraction Test (Room Ambient)

10.1.1 Repeat 9.2.

10.2 Scissor Test (Room Ambient)

10.2.1 Repeat 9.3.

11.0 THERMAL VACUUM

The thermal vacuum tests contained in paragraphs 4.6 of Environmental Test Specification ATL0246 (two each, low temperature and high temperature) shall be performed on the Boom System. Operational and performance tests shall be conducted during this test to verify proper system operation under a thermal vacuum environment. Since the system is cyclically operated as its normal mode of operation, the system shall not have voltages applied during chamber temperature and pressure changes and stabilization. Voltages shall be applied only during operational performance tests. The sequence of thermal vacuum tests shall be Low Temperature, High Temperature, Low Temperature and High Temperature in that order. The test of 11.1 and 11.2 shall be performed during the first low temperature and first high temperature vacuum exposures, respectively, with the Tip Mass Assemblies in place and supported by suitable fixtures; the tests of 11.3 and 11.4 shall be performed during the second low temperature and the second high temperature vacuum exposures, respectively, with the Tip Mass Assemblies removed and the half system re-oriented to provide sufficient space for scissoring and boom deployment.Ensure that the system is connected to test console prior to chamber closing.

11.1 Tip Mass Release Test (Environmental)

11.1.1 This test shall be performed while the system is stabilized at low temperature-vacuum as given in the Environmental Test Specification and shall verify tip mass release capability in this environment.

11.1.2 Each tip mass shall be supported by a fixture which will permit the masses to move 3 to 4 inches without loading the boom elements when the tip masses release.

11.1.3 Ensure that all switches on the test console are in the "OFF" position.

11.1.4 Attach the test console to the Boom System cabling.

11.1.5 Place the power plugs in "BOOMS".

11.1.6 Turn power supply "ON" and set voltage to 30 VDC.

11.1.7 Apply a pulse to cable cutters by placing "SQUIBB FIRE "A" switch in the "ON" position. Turn switch "OFF".

CAUTION

Under no circumstances should this cycle be repeated before the expiration of one (1) second. "Check the tip mass release indicator on the test panel to see if the tip mass release switches have operated".

11.1.8 Apply a pulse to cable cutters by placing "SQUIBB FIRE "B" switch in the "ON" position. Turn switch "OFF".

CAUTION

Under no circumstances should this cycle be repeated before the expiration of one (1) second.

11.1.9 Check the tip mass release indicator on the test panel to see that the tip mass release switches have operated. Complete the tip mass release by placing "MOMENTARY" power switch in the "EXTEND" position a sufficient number of times to determine that both tip masses have been released. (DO NOT EXTEND MORE THAN 3 TO 4 INCHES). Record whether light lit on "A" or "B" command.

11.1.10 Turn power supply "OFF".

11.1.11 Return chamber to ambient pressure and temperature.

11.1.12 Remove Tip Masses from Boom Isolation Assys. Remove Tip Mass Release Mechanisms (TMRMs), replace cable cutters, and reinstall TMRMs per PS-597694.

11.1.13 Re-install and mechanically recage tip masses.

11.2 Tip Mass Release Test (Environmental)

11.2.1 This test shall be performed while the system is stabilized at high temperature-vacuum as given in the Environmental Test Specification and shall verify tip mass release in this environment.

11.2.2 Repeat 11.1.2 through 11.1.11 except 11.1.6 shall be 22 VDC.

11.2.3 Remove both Tip Mass Assemblies by cutting Boom Element immediately behind the Boom Isolation Assembly.

11.3 <u>Extension-Retraction and Scissoring Performance (Ambient)</u>

11.3.1 This test shall be performed while the system is at ambient temperature and vacuum and shall provide a basis for comparison with system performance during High and Low Thermal Vacuum stabilization.

11.3.2 Ensure that all switches on the Test Console are in the "OFF" position and that the test console and Boom System are connected through connector J1.

11.3.3 Set the test console for BOOMS.

11.3.4 After environmental stabilization, turn power supply "ON" and set voltage at 22 VDC. Record chamber temperature and pressure and soak time.

CAUTION

Visual observation of the boom elements is required during the extension-retraction to ensure that elements are not damaged by either striking the walls of the environmental test chamber or by being retracted too far into the deployers.

11.3.5 During extension-retraction, the following information shall be recorded by means of Sanborn recorder, digital voltmeter, and recording instrument with thermocouples from environmental chambers

(1) Output of the extension read out potentiometers.

(2) Current of the boom system.

(3) Temperature of the system deployer motors.

(4) Photograph starting current spikes and transients.

11.3.6 "EXTEND" the boom elements approximately 1-1/2 feet. Record as a check mark. Record maximum motor current.

11.3.7 "RETURN" the boom elements to approximately 0.25 feet. Record.

11.3.8 Repeat 11.3.5, 11.3.6, 11.3.7 at 30 VDC. Record max. motor current.

11.3.9 Set the test console for "SCISSOR".

11.3.10 Set voltage at 22 VDC.

11.3.11 Scissor the deployers from the maximum angle limit switches to the minimum angle limit switches and from the minimum angle limit switches to the maximum angle limit switches. Record that angle limit switch lights come "ON".

11.3.12 During the scissor test, the following information shall be recorded by means of the Sanborn recorder and digital voltmeter.

(1) Scissor motor current.

(2) Scissor potentiometer output.

(3) One second time intervals.

(4) Temperature of the scissor motor housing.

(5) Photograph starting current spikes and transients.

11.3.13 Using the recorded data, calculate the scissoring rate.

11.3.14 Repeat 11.3.11, 11.3.12, and 11.3.13.

11.3.15 Turn power supply "OFF".

11.4 Extension-Retraction and Scissoring Performance (Environmental)

11.4.1 This test shall be performed while the system is stabilized at the low temperature - vacuum as given in the Environmental Test Specification and shall verify cold start capability in a vacuum environment .

11.4.2 After 8 hours of temperature stabilization repeat 11.3.2 through 11.3.15 twice at each voltage.

11.4.3 Approximately 8 hours after environmental re-stabilization repeat 11.3.2 through 11.3.15 twice at each voltage.

11.4.4 Repeat 11.4.3.

11.5 Extension-Retraction and Scissoring Performance (Environmental)

11.5.1 This test shall be performed while the system is stabilized at the high temperature - vacuum as given in the Environmental Test Specification.

11.5.2 After 8 hours of temperature stabilization, repeat 11.3.2 through 11.3.15 twice at each voltage.

11.5.3 Approximately 8 hours after environmental re-stabilization repeat 11.3.2 through 11.3.15 twice at each voltage.

11.5.4 Repeat 11.5.3.

12.0 POST-QUALIFICATION CHECK

The post-qualification check consists of those tests (room ambient) and inspections necessary to ensure that the Boom System has satisfactorily completed the environmental qualification test, that the design is qualified and that the system complies with the requirements of S-460-P-1.

Before performing the post-qualification check, Boom Isolation Assemblies

(418R439G01) shall be soldered to the Boom Elements per assembly drawing 662R808 and the Tip Masses (515R225G01 and 515R258G01) shall be attached per assembly drawing 613R771 and 613R772.

12.1 Visual Mechanical Inspection

Check the unit for general appearance and note on the data sheet any conditions such as corrosion, looseness, deformation, or other degradation. Complete this inspection after 12.9.

12.2 Insulation Resistance Test

12.2.1 Repeat 5.4.

12.3 Dielectric Strength Test

12.3.1 Repeat 5.5.

12.4 Electrical Isolation Test

12.4.1 Repeat 5.6.

12.5 Tip Mass Release

12.5.1 Repeat 5.8.

12.6 Extension and Retraction Test

12.6.1 Repeat 5.9

12.7 Scissor Test

12.7.1 Repeat 5.10 except omit 5.10.19.

12.8 Leak Test

12.8.1 Measure "half system" leak rate by repeating 5.7.2.

12.9 Deployer Slip Clutch Torque Test

Remove both deployers from the "half system" and measure the slip clutch torque of each per PS598213. The recorded value shall be 45 $\pm\frac{.5}{10}$ oz-in.

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13.0 QUALIFICATION TEST DATA SHEETS

13.1 SYSTEM IDENTIFICATION

Half System Serial Number	0001
Control Circuit Serial Number	~~[illegible]~~ 0001
Deployer A2 Serial Number (master)	0001
Motor Assembly Serial Number	0001
Deployer A3 Serial Number (RS73 slave)	0001
Motor Assembly Serial Number	0002
Scissor Mechanism Assembly Serial Number	0001
Squib Firing Circuit Assembly Serial Number	0001
Boom Element Serial Number A2 Deployer	163
Boom Element Serial Number A3 Deployer	161

13.2 PRE-QUALIFICATION CHECK (Paragraph 5.0)

13.2.1 Straightness Test (Paragraph 5.1)

Deployer A2 Boom Element Straightness: ☐

Deployer A3 Boom Element Straightness: ☐

NOT PERFORMED
TO BE WAIVED
J R Shively
2/18/69

13.2.2 Visual and Mechanical Inspection (Paragraph 5.2)

Conformance with 662R808 ☐

Notes:

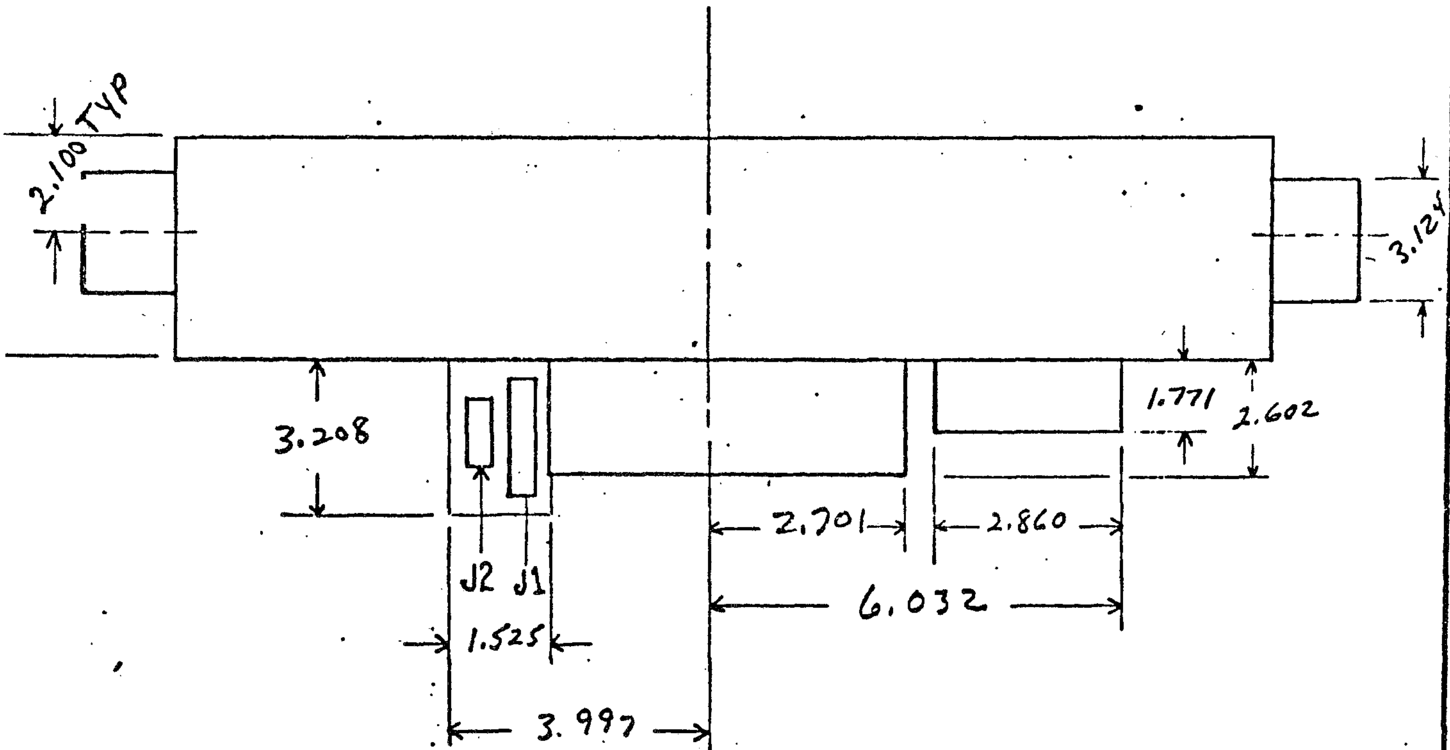

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Figure 2

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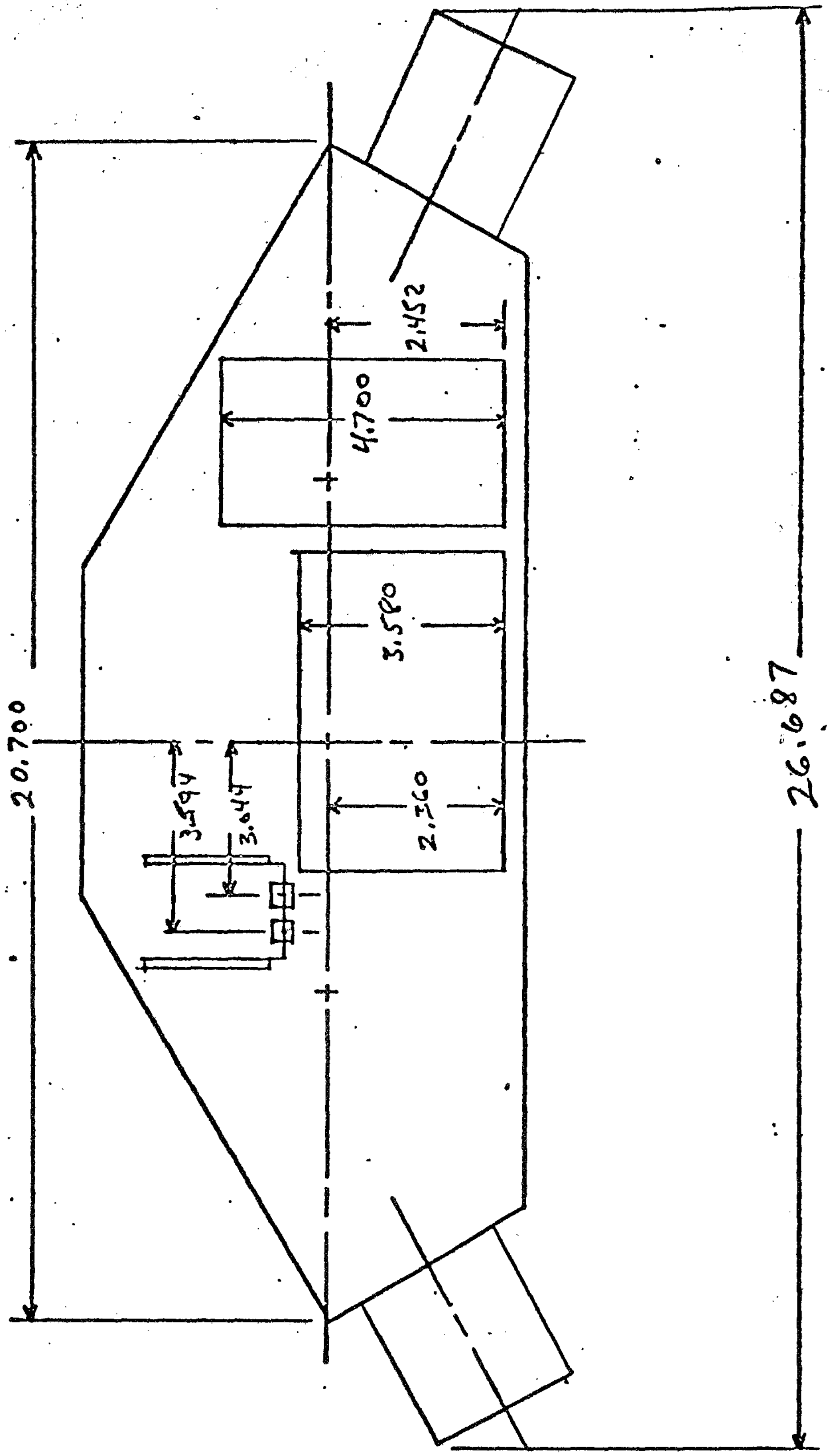

Figure 3

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Diameter of mounting bolt holes:

.2492 C44 AWA 1349	0.2500 + 0.0005 diameter
.2492 C44 AWA 1349	0.2500 + 0.0005 diameter
.2492 C44 AWA 1349	0.2500 + 0.0005 diameter

Weight of half system: ____________
(With tip masses) (39.14 pounds maximum)

	A2 Deployer	A3 Deployer
Tip Mass Assembly Weight (7.535 ±0.035 lbs maximum)	7.55 lbs	7.55 lbs
Boom Element Adhesion Test	☑	☑
Slip Clutch Torque (45 ±5 oz-in)	45 oz-in	45 oz-in

13.2.3 Circuit Isolation, D. C. Resistance and Continuity Test (Paragraph 5.3)

13.2.3.1 Circuit Isolation (Paragraph 5.3.1)

J1 PINS From	J1 PINS To	$> 5 \times 10^6$ ohms	J1 PINS From	J1 PINS To	($> 5 \times 10^6$ ohms)
1	5	✓	1	25	✓
	6	✓		26	✓
	7	✓		27	✓
	8	✓	1	28	✓
	9	✓		30	✓
	15	✓	7	33	✓
	18	✓		37	✓
	21	✓		8	✓
	22	✓		26	✓
	23	✓		27	✓
	24	✓		30	✓

J1 PINS From	J1 PINS To	$> 5 \times 10^6$ ohms
5	7	✓
	8	✓
	9	✓
	15	✓
	18	✓
	21	✓
	22	✓
	23	✓
	24	✓
	25	✓
	26	✓
	27	✓
	28	✓
	30	✓
	33	✓
	37	✓
8	9	✓
	15	✓
	18	✓
	21	✓
	22	✓
	23	✓
	24	✓
	25	✓
	30	✓
	33	✓
	37	✓
9	23	✓
	25	✓

J1 PINS From	J1 PINS To	$> 5 \times 10^6$ ohms
9	26	✓
	27	✓
	30	✓
15	26	✓
	27	✓
	30	✓
18	26	✓
	27	✓
	30	✓
22	26	✓
	27	✓
	30	✓
23	24	✓
	26	✓
	27	✓
	28	✓
	30	✓
	33	✓
	37	✓
26	27	(>18Kohms)
	28	✓
	30	✓
	33	✓
	37	✓
27	28	✓
	30	✓
	33	✓
	37	✓
30	33	✓
	37	✓

13.2.3.2 D. C. Resistance and Continuity (Paragraph 5.3.2)

J1 PINS From	J1 PINS To	RESISTANCE (ohms) Req'd	RESISTANCE (ohms) Actual	J1 PINS From	J1 PINS To	RESISTANCE (ohms) Req'd	RESISTANCE (ohms) Actual
1	5	$> 5 \times 10^6$	∞	18	21	0	0.1Ω
7	28	0 + 1	0		37	3,300±500	3.5K
8*	26	1	8K				
	27	1	8K	21	37	3,300±500	3.5K
9	24	0 + 1	0.1Ω				
				33*	21	1	3.5K
15*	18	1	3.5K		37	1	650Ω
	21	1	3.5K				
	37	1	325K				
17**	21	4,300	4.5K	36*	21	4,300±500	4.4K

1 Record measured valve

*Indicates terminal positive with respect to others

**Indicates terminal negative with respect to others

13.2.4 Insulation Resistance Test (Paragraph 5.4)

MEASURED FROM PINS OF J1 TO STRUCTURE

USING 100 VDC	$> 1 \times 10^7$ ohms	USING 100 VDC	$> 1 \times 10^7$ ohms
5	✓	7	✓
6	✓	9	✓
23	✓	18	✓
25	✓	24	✓
		28	✓

MEASURED FROM PINS OF J2 TO STRUCTURE	
USING 200 VDC	$>5x10^7$ ohms ✓
A1	✓
A2	✓

13.2.5 Dielectric Strength Test (Paragraph 5.5)

MEASURED FROM PINS OF J1 TO STRUCTURE			
USING 100 VAC	60 Hz	No Breakdown	✓
5			✓
6			✓
7			✓
9			✓
18			✓
23			✓
24			✓
25			✓
28			✓
MEASURED FROM PINS OF J2 TO STRUCTURE			
USING 200 VAC	60 Hz	No Breakdown	✓
A1			✓
A2			✓

13.2.6 Electrical Isolation Test (Paragraph 5.6)

13.2.6.1 Resistance (Paragraph 5.6.1)

Between elements of deployers A2 and A3	1.5×10^{10}
Element of deployer A2 to structure	0.95×10^{10}
Element of deployer A3 to structure	0.57×10^{10}

(Requirement: not less than 100 megohms)

13.2.6.2 Capacitance (Paragraph 5.6.2)

	@250KHz @2.5MHz
Between element of deployers A2 and A3	
Element of deployer A2 to structure	
Element of deployer A3 to structure	

(Requirement: Not greater than 200 pf)

13.2.6.3 Contact Resistance (Paragraph 5.6.3)

PIN A1 of J2 to element of deployer A2	.13
PIN A2 of J2 to element of deployer A3	.13

(Requirement: Not greater than 0.100 ohms)

13.2.7 Leak Test (Paragraph 5.7)

Scissor mechanism leak tested:	☑	
Scissor mechanism atmosphere:		(per T789491)
Scissor mechanism pressure:		(15±1.0psia)
Motor housing deployer A2 leak tested:	☐	
Motor housing deployer A2 atmosphere:		(per T789490)
Motor housing deployer A3 pressure:		(15 ±1.0 psia)
Motor housing deployer A3 leak tested:	☐	
Motor housing deployer A3 atmosphere:		(per T789490)
Motor housing deployer A3 pressure:		(15 ±1.0 psia)

Leak rate of half system: 2.6×10^{-8} cc/sec

(Requirement: Not greater than 3 x 10-6 std cc/sec of Helium)

13.2.8 Tip Mass Release (Paragraph 5.8)

		Light "ON"
Tip mass deployer A2 unlatched:	☑ RSS 1/3/68	☐
Tip mass deployer A3 unlatched:	☑	☐

13.2.9 Extension and Retraction Test (Paragraph 5.9)

	Deployer ~~A2~~ A3	Deployer ~~A3~~ A2
Limit switch light ~~"ON"~~ OFF	☑	☑
Length of element (>130 ft)	<130	<130
Reference mark location (48±1/32 in)	REF MARK @	12 INCHES
Extension rate at 22 VDC (0.60±.15 ft/sec)	0.42 ft/sec	0.42 ft/sec
Extension current at 22 VDC (Max) (N.A.)	1.3 amps	1.4 (*2) amps
Retraction rate at 22 VDC (0.60± .15 ft/sec)	0.46 ft/sec	0.38 ft/sec
	(slave)	(master)

* Spikes

Retraction current at 22 VDC (N. A)	2.2 amps	2.25 (2.5*) amps
Limit switch light ~~"OFF"~~ ON	☐	☐
Limit switch light ~~"ON"~~ OFF	☐	☐
Reference mark location (48±2.5 in) Mark @ 12 inches	✓	✓
Extension rate @30 VDC(0.60±15 ft/sec)		0.53 ft/sec
Extension current @30 VDC(1.0amp max)		1.25(1.5*) amps ~~[illegible]~~
Retraction rate @30 VDC(0.60±15ft/sec)		0.65 ft/sec
Retraction current @30 VDC(1.0 amp max)		2.0(2.5*) amps
Limit switch light "~~OFF~~ ON"	☐	☐
Boom element O. D. @25 ft. (0.50 ±.02 in)		
@50 ft		
@75 ft		
@100 ft.		
@end - 1 ft		

13.2.10 Scissor Test (Paragraph 5.10)

	Slave Deployer A2		Master Deployer A3
Latching angle (18.3 ±0.5°)	18°0'		18°8'
Potentiometer - ratio		2.875 / 5.002	
Maximum angle limit switch light "ON" AT 22 VDC		☐	
Maximum angle (28.0±0.5°)	27°0'		27°33'
Potentiomenter ratio -		0.650 / 5.004	
Minimum angle limit switch light "ON"		☐	
Minimum angle (13.0 ±0.5°)	12°7'		12°52'
Potentiometer ratio -		4.224 / 5.004	
Maximum to minimum average, scissor rate (1/8 ±1/16 deg/sec)		0.0992 deg/sec	
Motor current (maximum) (N.A.)		1.75 amps	
Maximum angle limit switch light "~~ON~~ OFF"		☐	
Minimum to maximum average scissor rate (1/8±1/16 deg/sec)		0,0992 deg/sec	

1/16 = .0625
3/16 = .1875

* Spikes (current)

Motor current (maximum) (M.A.) ____

AT 30 VDC

Minimum angle limit switch light "ON" ☐

Maximum to minimum average scissor rate (1/8 ±1/16 deg/sec) ____

Motor current (maximum) (0.66amp) ____

Maximum angle limit switch light "ON" ☐

Minimum to maximum scissor rate (1/8 ±1/16 deg/sec) ____

Motor current (maximum) (0.66 amp) ____

Latching angle (18.3 ± 0.5 °) 18°2′ 18°8′

Potentiometer voltage ratio $\frac{2.873}{5.004}$

Resistance

	Max Angle	Min. Angle
Between elements of deployers A2 and A3	1.3×10^{10}	0.6×10^{10}
Element of deployer A2 to structure	0.6×10^{10}	0.5×10^{9}
Element of deployer A3 to structure	0.85×10^{10}	0.52×10^{9}

(Requirement: not less than 100 megohms)

Capacitance

	@250 KHz	@2.5 MHz	@250 KHz	@2.5 MHz
Between elements of deployers A2 and A3				
Element of deployer A2 to structure				
Element of deployer A3 to structure				

(Requirement: Not greater than 200 pf)

13.3 HIGH AND LOW TEMPERATURE NON OPERATIONAL (Paragraph 6.0)

This test combined with Thermal Vacuum.

13.4 HIGH AND LOW TEMPERATURE OPERATIONAL (Paragraph 7.0)

This test combined with Thermal Vacuum.

13.5 HUMIDITY (Paragraph 8.0)

(NO TEST TO BE PERFORMED)

13.6 VIBRATION (Paragraph 9.0)

13.6.1 Tip Mass Release (Paragraph 9.1) ~~Light "ON"~~

Tip mass deployer A2 unlatched: ☑ ☐

Tip mass deployer A3 unlatched: ☑ ☐

2/1/69

13.6.2 Extension and Retraction Test (Paragraph 9.2)

Length of element (>128 ft)	110'
Extension rate @22 VDC (0.60 ±0.15 ft/sec ave)	0.425 ft/sec
Extension current @22 VDC (max) (N.A.)	1.25 amps
Retraction rate @22 VDC (0.60 ±0.15 ft/sec ave)	0.33 ft/sec
Retraction current @22 VDC (max) (N.A.)	2.2 amps

Limit Switch light A2 Deployer OFF ~~ON~~ ☑ ON ~~OFF~~ ☑

Limit Switch light A3 Deployer ~~ON~~ ☑ OFF ~~OFF~~ ☑ ON

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13.6.3 Scissor Test (Paragraph 9.3)

Latching angle (±0.5° of pre-vibration value)	~~A2~~ 17° 59' ~~A3~~ 18° 2'
Latching angle potentiometer - ratio	2.794/5.008
Maximum angle limit switch light "~~ON~~ OFF"	☑ ANGLE: 27° 21' M 27° 8' S
Maximum angle potentiometer - ratio	-0.638/-5.012
Minimum angle limit switch light "~~ON~~ OFF"	☑ ANGLE: 12° 41' M 12° 58' S
Minimum angle potentiometer - ratio	-4.168/-5.012
Maximum angle limit switch "~~ON~~ OFF"	☑
Maximum angle potentiometer - ratio	-0.659/-5.013
Latching angle potentiometer - ratio 2/3/69	Angle 18° 8' M; 18° 15' S -2.816/-5.001
Scissor rate maximum to minimum(1/8 ±1/16 deg/sec)	0.1018 deg/sec.
Maximum motor current (N.A.)	~~0.1047~~ 1.5 amps
Scissor rate minimum to maximum(1/8 ±1/16 deg/sec)	0.1047
Maximum motor current (N.A.)	1.5 amps

13.7 ACCELERATION (Paragraph 10.0)

13.7.1 Extension and Retraction Test (Paragraph 10.1)

Length of element (>126 ft)	110'
Extension rate @22 VDC (0.60 ±0.15 ft/sec ave)	0.43 ft/sec
Extension current @22 VDC (max) (N.A.)	1.3 amps
Retraction rate @22 VDC (0.60 ±0.15 ft/sec ave)	0.36 ft/sec
Retraction current @22 VDC (max) (N.A.)	1.8 amps
Limit Switch light A2 Deployer ON ☐	OFF ☐
Limit Switch light A3 Deployer ON ☐	OFF ☐

NOTE: 44 1/2 ft. cut off of slave boom

Post Acceleration 2/4/69 Tip Mass-Release test performed as per para 9.1 performed satisfactorily. [signature]

13.7.2 Scissor Test (Paragraph 10.2)

Latching angle potentiometer output ratio	-2.818/-5.007
Maximum angle limit switch light "~~ON~~ OFF"	☑
Maximum angle potentiometer - output ratio	-0.592/-5.000
Minimum angle limit switch light "~~ON~~ OFF"	☑
Minimum angle potentiometer output ratio	-4.192/-5.000
Maximum angle limit switch light "~~ON~~ OFF"	☐
Maximum angle potentiometer output ratio	-0.592/-5.000

Latching angle potentiometer output ratio -2.843

Scissor rate maximum to minimum(1/8 ±1/16 deg/sec) (152sec) .096 deg/sec

Maximum motor current (N. A.) 300ma

Scissor rate minimum to maximum(1/8 ±1/16 deg/sec) (148sec) 0.099 deg/sec

Maximum motor current (N. A.) 300ma

13.8 THERMAL VACUUM (Paragraph 11.0)

13.8.1 Tip Mass Release (Paragraph 11.1)

			~~Light "ON"~~ No lights
Tip mass deployer A2 unlatched:	2/9/69	☑	☐
Tip mass deployer A3 unlatched:		☑	☐

13.8.2 Tip Mass Release (Paragraph 11.2)

			Light ~~"ON"~~
Tip mass deployer A2 unlatched:	2/11/69	☑	☐
Tip mass deployer A3 unlatched:		☑	☐

13.8.3 Extension - Retraction and Scissoring Performance (Paragraph 11.3)

2/18/69

Chamber Pressure Ambient

Chamber Temperature ambient

Soak Time after Stabilization — N/A

Extension @22 VDC ☑

Retraction @22 VDC ☑

Maximum system current @22 VDC (N. A.) 2.25 amps

Extension @30 VDC ☑

Retraction @30 VDC ☑

Maximum system current @30 VDC (1.0 amp) 2.10 amps

Scissoring @22 VDC ☑

Maximum angle limit switch light "ON" ☑

Minimum angle limit switch light "ON" ☑

Scissor rate maximum to minimum(1/8 ±1/16 deg/sec) (159sec) 0.089 deg/sec

Scissor rate minimum to maximum (1/8±1/16 deg/sec) 156sec 0.090 deg/sec

Maximum scissor current @22 VDC (N. A.) 260ma

Scissoring @ 30 VDC ☐

Maximum angle limit switch light "ON" ☐

Minimum angle limit switch light "ON" ☐

Scissor rate maximum to minimum(1/8 ±1/16 deg/sec) 142sec 0.103 deg/sec

Scissor rate minimum to maximum(1/8 ±1/16 deg/sec) 148sec 0.099 deg/sec

Maximum scissor current @30 VDC (0.66 amp)	350 ma	

13.8.4 Extension-Retraction and Scissoring Performance (Paragraph 11.4)

2/19/69

Chamber Pressure	6.2×10^{-6}	6.2×10^{-6}
Chamber Temperature	-6°F	-4°F
Soak Time after Stabilization	2½ hrs	3½ hrs
Extension @22 VDC	☑	☑
Retraction @22 VDC	☑	☑
Maximum system current @22 VDC (N.A.)	* 2.65amps	2.65amps
Extension @30 VDC	☑	☑
Retraction @30 VDC	☑	☑
Maximum system current @30 VDC (1.0 amp)	* 2.50amps	2.65amps
Scissoring @22 VDC	☑	☑
Maximum angle limit switch ~~light "ON"~~	☑	☑
Minimum angle limit switch ~~light "ON"~~	☑	☑
Scissor rate maximum to minimum(1/8 ±1/16 deg/sec)	178sec	175sec
Scissor rate minimum to maximum(1/8 ±1/16 deg/sec)	175sec	171sec
Maximum scissor current @22 VDC (N.A.)	450 ma	400 ma
Scissoring @30 VDC	☑	☑
Maximum angle limit switch ~~light "ON"~~	☑	☑
Minimum angle limit switch ~~light "ON"~~	☑	☑
Scissor rate maximum to minimum(1/8 ±1/16 deg/sec)	147sec	145sec
Scissor rate minimum to maximum(1/8 ±1/16 deg/sec)	144sec	142sec
Maximum scissor current @30 VDC (0.66 amp)	550ma	450ma

Extension - Retraction and Scissoring Performance (Paragraph 11.4)

2/20/69

Chamber Pressure	6×10^{-6}	4.5×10^{-6}
Chamber Temperature	-7°F	-5°F
Soak Time after Stabilization	22hrs	23hrs
Extension @22 VDC	☑	☑
Retraction @22 VDC — Did not Retract @22 VDC; Retracted @25 VDC	☑	☑
Maximum system current @22 VDC (N.A.)	OFF SCALE >2.65amps	>2.65
Extension @30 VDC	☑	☑
Retraction @30 VDC	☑	☑
Maximum system current @30 VDC (1.0 amp)	OFF SCALE >2.65	** 3.0amps
Scissoring @22 VDC	☑	☑

* Note current scale was bottom out and actual current was higher by an unknown amount.
** Changed Scale

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Maximum angle limit switch ~~"light "ON"~~	☑	✓
Minimum angle limit switch ~~"light "ON"~~	☑	✓
Scissor rate maximum to minimum(1/8 ±1/16 deg/sec)	176sec	147sec
Scissor rate minimum to maximum(1/8 ±1/16 deg/sec)	171sec	141sec
Maximum scissor current @22 VDC (N.A.)	450ma	400ma
Scissoring @30 VDC	☑	✓
Maximum angle limit switch ~~"light "ON"~~	☑	✓
Minimum angle limit switch ~~"light "ON"~~	☑	✓
Scissor rate maximum to minimum(1/8 ±1/16 deg/sec)	174sec	146 sec
Scissor rate minimum to maximum(1/8 ±1/16 deg/sec)	168sec	140sec
Maximum scissor current @30 VDC (0.66 amp)	500ma	475ma
Extension - Retraction and Scissoring Performance (Paragraph 11.4)		
2/20/69 Chamber Pressure	5.6×10^{-6}	6.2×10^{-6}
Chamber Temperature	-5°F	-4°F
Soak Time after Stabilization	24 1/2 hrs	25 1/2 hrs
Extension @22 VDC	☑	☑
Retraction @22 VDC {Does not retract @22VDC / Retracts and stops at 25VDC / Retracts properly @27VDC}	☑	✓
Maximum system current @22 VDC (N.A.)	3.3amp	3.3a
Extension @30 VDC	☑	✓
Retraction @30 VDC	☑	✓
Maximum system current @30 VDC (1.0 amp)	3.0amps	3.0a
Scissoring @22 VDC	☑	✓
Maximum angle limit switch ~~"light "ON"~~	☑	✓
Minimum angle limit switch ~~"light "ON"~~	☑	✓
Scissor rate maximum to minimum(1/8 ±1/16 deg/sec)	175sec	172sec
Scissor rate minimum to maximum(1/8 ±1/16 deg/sec)	170sec	167sec
Maximum scissor current @22 VDC (N.A.)	400ma	375ma
Scissoring @30 VDC	☑	✓
Maximum angle limit switch ~~"light "ON"~~	☑	✓
Minimum angle limit switch ~~"light "ON"~~	☑	✓
Scissor rate maximum to minimum(1/8±1/16 deg/sec)	144sec	142sec
Scissor rate minimum to maximum(1/8±1/16 deg/sec)	140sec	140sec
Maximum scissor current @30 VDC (0.66 amp)	475ma	475ma

13.8.5 Extension - Retraction and Scissoring Performance (Paragraph 11.5)

2/21/69

Chamber Pressure	6.2×10^{-6}	6.2×10^{-6}
Chamber Temperature	140°F	141°F
Soak Time after Stabilization	2 hrs	3 hrs
Extension @22 VDC	✓	✓
Retraction @22 VDC {RETRACT AT 27VDC NOT @22 VDC}	✓	✓
Maximum system current @22 VDC (N.A.)	2.7a	2.6a
Extension @30 VDC	✓	✓
Retraction @30 VDC	✓	✓
Maximum system current @30 VDC (1.0 amp)	2.5a	2.8a
Scissoring @22 VDC	✓	✓
Maximum angle limit switch ~~light "ON"~~	✓	✓
Minimum angle limit switch ~~light "ON"~~	✓	✓
Average scissor rate maximum to minimum (1/8 ±1/16 deg/sec)	138sec	138sec
Average scissor rate minimum to maximum (1/8 ±1/16 deg/sec)	136sec	135sec
Maximum scissor current @22 VDC (N.A.)	280ma	275ma
Scissoring @30 VDC	✓	✓
Maximum angle limit switch ~~light "ON"~~	✓	✓
Minimum angle limit switch ~~light "ON"~~	✓	✓
Average scissor rate maximum to minimum (1/8 ±1/16 deg/sec)	125sec	125sec
Average scissor rate minimum to maximum (1/8 ± 1/16 deg/sec)	122sec	122sec
Maximum scissor current @30 VDC (0.66 amp)	310ma	325ma

Extension - Retraction and Scissoring Performance (Paragraph 11.5)

2/21/69

Chamber Pressure	5.6×10^{-6}	5.8×10^{-6}
Chamber Temperature	140°F	141°F
Soak Time after Stabilization	6 1/2 hrs	7 1/2 hrs
Extension @22 VDC	✓	✓
Retraction @22 VDC (Retraction at 28VDC)	✓	✓
Maximum system current @22 VDC (N.A.)	2.7a	2.7a
Extension @30 VDC	✓	✓
Retraction @30 VDC	✓	✓

Maximum system current @30 VDC (1.0 amp)	2.9a	2.7a
Scissoring @22 VDC	☑	☑
Maximum angle limit switch ~~light "ON"~~	☑	☑
Minimum angle limit switch ~~light "ON"~~	☑	☑
Average scissor rate maximum to minimum (1/8 ±1/16 deg/sec)	139 sec	136 sec
Average scissor rate minimum to maximum (1/8 ± 1/16 deg/sec)	134 sec	133 sec
Maximum scissor current @22 VDC (N.A.)	275ma	275ma
Scissoring @30 VDC	☑	☑
Maximum angle limit switch ~~light "ON"~~	☑	☑
Minimum angle limit switch ~~light "ON"~~	☑	☑
Average scissor rate maximum to minimum (1/8 ± 1/16 deg/sec)	125 sec	124 sec
Average scissor rate minimum to maximum (1/8 ± 1/16 deg/sec)	122 sec	120 sec
Maximum scissor current @30 VDC (0.66 amp)	350ma	325ma
<u>Extension-Retraction and Scissoring Performance (Paragraph 11.5)</u>		
2/22/69 Chamber Pressure	5.2×10^{-6}	5.4×10^{-6}
Chamber Temperature	140°F	141°F
Soak Time after Stabilization	30 1/2 hrs	32 hrs
Extension at 22 VDC	☑	☑
Retraction at 22 VDC {RETRACT @28 VDC}	☑	☑
Maximum system current at 22 VDC (N.A.)	2.6a	2.6a
Extension at 30 VDC	☑	☑
Retraction at 30 VDC	☑	☑
Maximum system current at 30 VDC (1.0 amp)	2.8a	2.7a
Scissoring at 22 VDC	☑	☑
Maximum angle limit switch ~~light "ON"~~	☑	☑
Minimum angle limit switch ~~light "ON"~~	☑	☑
Average scissor rate maximum to minimum (1/8 ±1/16 deg/sec)	136 sec	136 sec
Average scissor rate minimum to maximum (1/8 ±1/16 deg/sec)	134 sec	133 sec
Maximum scissor current at 22 VDC (N.A.)	275ma	275ma

Scissoring at 30 VDC	☑	☑
Maximum angle limit switch ~~"light ON"~~	☑	☑
Minimum angle limit switch ~~"light ON"~~	☑	☑
Average scissor rate maximum to minimum (1/8 ±1/16 deg/sec)	124 sec	124 sec
Average scissor rate minimum to maximum (1/8 ±1/16 deg/sec)	123 sec	122 sec
Maximum scissor current at 30 VDC (0.66 amp)	350 ma	350 ma

NOTE

NOTE: Spikes appear on scissor current (max value ~ 400 ma)

13.9 POST-QUALIFICATION CHECK (Paragraph 12.0)

13.9.1 General Mechanical Inspection (Paragraph 12.1)

Note descrepancies below:

13.9.2 Insulation Resistance Test (Paragraph 12.2)

MEASURED FROM PINS OF J1 TO STRUCTURE

USING 100 VDC	$> 1 \times 10^7$ ohms	USING 100 VDC	$> 1 \times 10^7$ ohms
	✓		✓
5	✓	18	✓
6	✓	23	✓
7	✓	24	✓
9	✓	25	✓
		28	✓

MEASURED FROM PINS OF J2 TO STRUCTURE		
USING 200 VDC	>5 x10^7 ohms	✓
A1		✓
A2		✓

13.9.3 Dielectric Strength Test (Paragraph 12.3)

MEASURED FROM PINS OF J1 TO STRUCTURE		
USING 100 VAC 60 HZ	No Breakdown	✓
5		✓
6		✓
7		✓
9		✓
18		✓
23		✓
24		✓
25		✓
28		✓

MEASURED FROM PINS OF J2 TO STRUCTURE		
USING 200 VAC 60 Hz	No Breakdown	✓
A1		✓
A2		✓

13.9.4 Electrical Isolation Test Paragraph 12.4)

13.9.4.1 Resistance (Paragraph 5.6.1)

Element of deployer A2 to element of deployer A3	8 X 10^{10} ohms
Element of deployer A2 to structure	4.4 X 10^{10}
Element of deployer A3 to structure	3.6 X 10^{10}
(Requirement: Not less than 100 megohms)	

13.9.4.2 Capacitance (Paragraph 5.6.2)	@250 KHz	@ 2.5 MHz
Element of deployer A2 to element of deployer A3	36.5pf	37pf
Element of deployer A2 to structure	117.5pf	121.5pf

CABLE 4.5"

Element of deployer A3 to structure	118.5pf | 121.5 pf
(Requirement: Not greater than 200 pf)	

13.9.4.3 Contact Resistance (Paragraph 5.6.3)

PIN A1 of J2 to element of deployer A2	0.175 ohm
PIN A2 of J2 to element of deployer A3	0.143 ohms
(Requirement: Not greater than 0.100 ohms)	

13.9.5 Tip Mass Release (Paragraph 12.5)

		Light "ON"
Tip mass deployer A2 unlatched:	1816 AIA ☑ D.D.T.	☐
Tip mass deployer A3 unlatched:	1816 AIA ☑	☐

13.9.6 Extension and Retraction (Paragraph 12.6)

	Deployer A2	Deployer A3
Limit switch light ~~"ON"~~	☑	☑
Length of element (> 123 ft)	105 1/2'	105 1/2'
Extension rate @22 VDC (0.60 ±0.15 ft/sec ave)		
Extension current @22 DDC (max) (N.A.)		
Retraction rate @22 VDC (0.60 ±0.15 ft/sec ave)		
Retraction current @22 VDC (max) (N.A.)		
Limit switch ~~light "OFF"~~	☑	☑
Limit switch ~~light "ON"~~	☑	☑
Extension rate @30 VDC (0.60 ±0.15 ft/sec ave)		
Extension current @30 VDC (1.0 amp max)		
Retraction rate @30 VDC (0.60 ±0.15 ft/sec)		
Retraction current @30 VDC (1.0 amp max)		
Limit switch ~~light~~ "OFF"	☑	☑
N/A Boom element O.D. @25 ft		
@50 ft		
@75 ft		
@100 ft		

13.9.7 Scissor Test (Paragraph 12.7)

	Deployer A2	Deployer A3
Latching angle (18.3 ±0.5°)	17°50'	17°12'
Potentiometer - ratio	-2.979/-5.005	
AT 22 VDC		
Maximum angle limit switch "ON"	☑	
Maximum angle (28.0 ±0.5°)	27°50'	27°23'
Potentiometer - ratio	-0.514/-5.005	
Minimum angle limit switch "ON"	☑	
Minimum angle (13.0 ±0.5°)	12°57'	12°16'
Potentiometer - ratio	-4.246/-5.004	
Maximum to minimum average scissor rate (1/8 ± 1/16 deg/sec)		
Motor current (maximum)(N. A.)		
Maximum angle limit switch light "ON"	☐	
Minimum to maximum average scissor rate (1/8 ±1/16 deg/sec)		
Motor current (maximum) (N. A.)		
AT 30 VDC		
Minimum angle limit switch light "ON"	☐	
Maximum to minimum average scissor rate (1/8 ±1/16 deg/sec)		
Motor current (maximum)(0.66 amp)		
Maximum angle limit switch light "ON"	☐	
Minimum to maximum average scissor rate (1/8 ±1/16 deg/sec)		
Motor current (maximum)(0.66 amp)		

Resistance	Max Angle	Min. Angle
Between elements of deployer A2 and A3		
Elements of deployer A2 to structure		
Element of deployer A3 to structure		

(Requirements: Not less than 100 megohms)

Capacitance DATA TAKEN WAS WITHIN SPECIFICATIONS BUT HAS BEEN MISPLACED.

	Max Angle @250 KHz	Max Angle @2.5 MHz	Min Angle @250 KHz	Min Angle @2.5 MHz
Between elements of deployers A2 and A3				
Element of deployer A2 to structure				
Element of deployer A3 to structure				

(Requirement: Not greater than 200 pf)

13.9.8 Leak Test (Paragraph 12.8)

Leak rate of half system WAIVED BY GSFC

Requirement: Not greater than 3×10^{-6} std cc/sec

13.9.9 Slip Clutch Torque (Paragraph 12.9)

A2 deployer ($45 \pm^{5}_{10}$ oz-in) 37 SLAVE

A3 deployer ($45 \pm^{5}_{10}$ oz-in) 56 MASTER

PAGE	CODE IDENT. NO.	SPECIFICATION NUMBER	REV
53	97942	T789493	

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ACTION: 2. ☐ DFTG. 3. ☐ MFG. 4. ☐ PROD. REL. 5. ☐ FIELD

6. AFFECTED: ☐ SPARES ☐ PURCHASING ☐ RELIABILITY ☐ ROUTING ☐ FACTORY TEST EQUIP. DWG. ☐ TOOLING ☐ FIELD SUPPORT EQUIP. ☐

28. RN-B5621.02 SUB.

SHEET 1 OF 4

7 CC	8 ACT	9 BC	10 ITEM	11 CIRCUIT SYMBOL	12 REQD	13 UM	14 CODE IDENT*	PART NUMBER	15 ACTUAL V/P/C	16 SPEC NO.*	NAME/DESCRIPTION/MATL	WT*	17 SYM	18 ICNHTG

2,3,4 ① IN SECTION 13.2.3.2 ADD THE FOLLOWING IN EXISTING TABLE:

J1 PINS		RESISTANCE (ohms)	
From	To	Req'd	Actual
10	29	0+1	

② UPDATE REVISION NUMBER WHERE REQUIRED.

RECEIVED MAR 24 1969 IN VAULT

ORIGINAL

19. REASON THIS CHECK WAS ERRONEOUSLY OMITTED. OTHER TEST PROCEDURES CHANGED

20. EQUIP. ATS BOOM | 21. UNIT QUALIFICATION TEST SPEC | 30. C.E.I. NO. — | 31. NEXT ASSY. | 32. LOWEST SERIALIZED ASSY. — | 33. B.I.P. — | 34. G.O. 5142 S.O. | 36. SUPERVISOR DATE 12/24/68

22. ORIGINATOR (PRINT) EXT. DATE: O.R. SHIVELY 6131 12/24/68

37. M.E. — 37A. I.E. —

23. DRAWING NAME: Q.T. SPEC

38. M.S.E./SPARES DATE —

24. P/L YES ☐ NO ☐ 25. E.C.P. NO.

39. 3/4/69

26. DRAWING NO. T789493 27. REV. TO C

40. 3/11/69

28. NO. SUB RN-B5621.02 29. REL. DATE 3-24-69 35. M.I. ACTION

41. C.C.B. ACTIVITY DATE 3/11/69

SHEET 1 OF 4 COMPLETE REVISION CONSISTS OF TO

42. CUSTOMER DATE

26 DWG. NO.	SHEET	NO.	SUB
T789493	2 OF 4	RN-B 5621.02	

7 CC	8 ACT	9 BC	10 ITEM	11 CIRCUIT SYMBOL	12 REQD	13 UM	14 CODE IDENT* / PART NUMBER	15 ACTUAL V/P/C	16 SPEC NO. *	NAME/DESCRIPTION/MATL	WT*	17 SYM	18 INCHG

(3) PAGE 5, CHANGE FROM: 10.1 TO: 10.2
10.2 TO: 10.3
ADD: 10.1 Tip Mass Release Test

(4) PAGE 6, PARA 4.2: AFTER "Test Console", ADD: or equivalent (General Electric PCU with switch box)

(5) PAGE 10, PARA 5.8.7: CHANGE FROM: Record TO: A positive indication of tip mass release switch activation shall be recorded as switch "ON".

(6) PAGE 12, PARA 5.9.10
PAGE 20, PARA 9.2.10
PAGE 27, PARA 11.3.11 } CHANGE FROM: --- switch lights shall come "ON". TO: --- switches shall actuate "ON"

(7) PAGE 13, PARA 5.9.16 CHANGE FROM: --- switch lights shall go "OFF." TO: --- switches shall deactuate "OFF"

(8) PAGE 16, PARA 5.10.5
PARA 5.10.10
PAGE 17 PARA 5.10.14
PAGE 22 PARA 9.3.5, 9.3.8 & 9.3.10 } CHANGE FROM: ~~switch~~ light shall come "ON." TO: ~~switch~~ shall actuate "ON"

(9) PAGE 16 PARA 5.10.6
PAGE 22 PARA 9.3.6 } CHANGE TO READ: During the following scissor test ---
DELETE THE LAST ITEM: Photograph ----- transients

(10) PAGE 18 PARA 9.1.1 ADD: except do not remove Boom Isolation Assy from slave boom.

(11) PAGE 19 PARA 9.2.5 CHANGE FROM: master deployer TO: slave deployer
AND FROM: slave deployer TO: master deployer

(12) PAGE 20 PARA 9.2.11 (a) CHANGE TO: Extended length of element and reference mark location

(13) PAGE 22 PARA 9.3.12 CHANGE FROM: 6.2.2 TO: 13.2.10

(14) PAGE 23 PARA 10.0 CHANGE FROM: 10.1 TO: 10.2 AND FROM 10.1.1 TO: 10.2.1
10.2 TO: 10.3 AND FROM 10.2.1 TO: 10.3.1
ADD: 10.1 Tip Mass Release Test
10.1.1 Repeat 5.8 except DO NOT remove Boom Isolation Assy from slave boom
ADD TO NEW PARA 10.3.1 TO READ: Repeat 9.3 except do not compare latching angle with previbration value

ORIGINAL

26 DWG. NO.	SHEET	NO.	SUB
T784493	3 OF 4	RN-B5621.02	

7 CC	8 ACT	9 BC	10 ITEM	11 CIRCUIT SYMBOL	12 REQD	13 UM	14 CODE IDENT* / PART NUMBER	15 ACTUAL V/P/C	16 SPEC NO. * / NAME/DESCRIPTION/MATL / WT*	17 SYM	18 INCH TG

(15) PAGE 24 PARA 11.0 SHOULD READ AS FOLLOWS: "----- by suitable fixtures; the tests of 11.3, 11.4 and 11.5 shall be performed immediately prior to the second low temperature, during the second low temperature and during the second high-----"

(16) PAGE 25 PARA 11.1.7 CHANGE TO READ: --- in the "ON" position for approximately (1) second. Turn switch "OFF"

AFTER CAUTION NOTE ADD: Repeat "SQUIBB FIRE 'A'" one or two times.

PARA 11.1.9 CHANGE TO READ: Check the ---- test panel (or check at Test Point Box with multimeter) to see that--- operated. Complete --- have been released. After MASTER boom has deployed approximately (1) inch, insert TEST RESISTOR into Test Point Box (Master deployer potentiometer wiper arm to ground) and deploy both booms an additional amount (approx (1) inch) with "MOMENTARY" DEPLOY switch. (DO NOT ----). Record whether switch operated on "A" or "B" command.

PARA 11.1.10 ADD: and remove TEST RESISTOR from Circuit

(17) PAGE 26 PARA 11.2.3 CHANGE TO READ: Remove both Tip Masses but leave the Boom Isolation Assy attached to each boom

PARA 11.3.2 ADD: INSERT TEST RESISTOR into Test Point Box (master deployer potentiometer wiper arm to ground) so that both booms will begin deployment simultaneously

PARA 11.3.4. AT END OF CAUTION NOTE ADD: Boom extended length prior to the next deploy test may be set by unequal individual deployer operation to insure that both deployers will be exercised (both deploy and retract) in the confined chamber space

(18) PAGE 27 PARA 11.3.5 DELETE: (3) Temperature ------ motors
PARA 11.3.6 CHANGE FROM 1-1/2 feet TO: 12 inches.
ADD: BE SURE TO REMOVE TEST RESISTOR FROM CIRCUIT
PARA 11.3.8 CHANGE TO: 11.3.8 Reinstall TEST RESISTOR as in 11.3.2 and repeat 11.3.5. -----
PARA 11.3.12 DELETE: (4) Temperature ----
DELETE: (5) Photograph -----

ORIGINAL

7 C C	8 A C T	9 B C	10 ITEM	11 CIRCUIT SYMBOL	12 REQD	13 UM	14 CODE IDENT* PART NUMBER	15 ACTUAL V/P/C	16 SPEC NO. *	26 DWG. NO. 1278949 3	SHEET 4 OF 4 NAME/DESCRIPTION/MATL	28 RN- B5621.02 WT*	NO. SUB	17 S Y M	18 I C N H T G

(19) PAGE 27 PARA 11.3.14 ADD: at 30 VDC.

(20) PAGE 28 PARA {11.5.2, 11.4.2} CHANGE TO READ: After stabilization is achieved, repeat 11.3.2 through 11.3.15 two times.
PARA 11.4.3 & 11.5.3 CHAGE FROM: -twice at each voltage- TO: - - -two times
PARA {11.4.4, 11.5.4} CHANGE TO READ: After a minimum total ~~[illegible]~~ soak time of 24 hours, repeat 11.3.2 through 11.3.15 two times.

(21) PAGE 36 PARA 13.2.3.2 ON RESISTANCE FROM J1, PIN 17, TO J1, PIN 21, CHANGE FROM: 4,300 TO: 4,300 ± 500

(22) PAGE 38 PARA 13.2.8
PAGE 41 PARA 13.6.1
PAGE 43 PARA 13.8.1
PARA 13.8.2
PAGE 51 PARA 13.9.5
} CHANGE FROM: Light "ON" TO: Switch "ON"

(23) PAGE 38 PARA 13.2.9
39 " " " " "
" 13.2.10
40 " " " "
42 " 13.6.3
" 13.7.1
" 13.7.2
43 " 13.8.3
44 " 13.8.4
45 " " " "
46 & 47 " 13.8.5
48 " " " "
51 " 13.9.6
52 " 13.9.7
} CHANGE FROM: Switch light "ON" TO: switch "ON"

(24) PAGE 39, PARA 13.2.9
PAGE 51, PARA 13.9.6 } CHANGE FROM: Switch light "OFF" TO: switch "OFF"

(25) PAGE 41, PARA 13.6.2 BENEATH "Length of element"
ADD: Reference Mark location (45 ± 2.5 m)

DELETE THE WORD "light" FROM LAST TWO LINES

(26) PAGE 42 PARA 13.7:
ADD AS FOLLOWS: 13.7.3 Tip Mass Release (Paragraph 10.1) switch "ON"
Tip mass deployer A2 unlatched ☐
Tip mass deployer A3 unlatched ☐

PARA 13.7.1 CHANGE From: (Paragraph 10.1) To: (Paragraph 10.2)
PARA 13.7.2 CHANGE FROM: (Paragraph 10.2) To: (Paragraph 10.3)

(24) PARA 13.2.3.1 ADD A DOUBLE ASTERISK ON FOLLOWING PIN TESTS: FROM: 1 TO: 15, 18, 21, 22, 33, 37 & FROM: 26 TO: 28
(25) PAGE 37, PAR 13.2.7 CHANGE LIMIT OF SCISSOR MECH ATMOSPHERE FROM: 15 ± 1 psia TO: 7.5 ± 1 psia

ORIGINAL

APPENDIX III

Special Harmonic Drive Testing

SPECIFICATION NUMBER T853589

REV LTR	DATE	REVISION NOTICE NUMBER	PAGES AFFECTED	APPROVED
A	6-4-69		All	V D Marone

REVISIONS

ORIGINALLY PREPARED FOR CONTRACT NO.	NAS 5-10285
ORIGINATOR J. Humphreys	J. Humphreys 6-4-69
V. Marone	V D Marone
S. May	S May 6/5/69
R. Wirth	R Wirth 6/5/69

Westinghouse Electric Corporation

AEROSPACE DIVISION BALTIMORE, MD., U.S.A.

TITLE

TEST PROCEDURE FOR THE GRAVITY-GRADIENT BOOM SPECIAL PROTOTYPE TESTING

PAGE 1 OF 10 PAGES	SPECIFICATION TYPE	CODE IDENT. NO.	SPECIFICATION NUMBER
	Append Pg III-2	97942	T853589

BA 5656-1

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REVISION LETTER

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DO NOT NUMBER BEYOND 100 IF AN ADDITIONAL INDEX PAGE IS REQUIRED

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	2	97942	T853589	A

BA 5656-2A

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this specification is to establish the thermal-vacuum test requirements for the "Special Prototype Testing of the Gravity-Gradient Boom System." These tests are intended to demonstrate the ability of the harmonic drive systems to meet the operational design performance requirements without harmful degradation under a thermal-vacuum environment and to generate data for predicting the useful life of the Gravity-Gradient Boom Drive System.

2.0 ADMINISTRATIVE PROCEDURE

2.1 Applicable Documents

Westinghouse Test Specification	ATL0246
NASA Test Specification	No. S2-0102
NASA Specification	S-460-P-1
Westinghouse ATL Drawing	EVT-SK-B3541

2.2 Test Facilities

The environmental test facilities used in conducting the test will be a NASA/GSFC furnished thermal-vacuum chamber which allows each boom to be deployed approximately four (4) feet.

2.3 Environmental Tolerances

Temperature: $\pm 2^{\circ}C$ ($\pm 4.0^{\circ}F$)

Pressure: less than 1.0×10^{-5} mmHG

2.4 Failures

If at anytime, the G/G Boom System demonstrates an inability to meet its operational design performance requirements, the testing will be stopped. Upon investigation of the problems envolved, a joint decision by the parties envolved (NASA/GSFC and Westinghouse) will be made as to the termination of the test. (see section 2.5)

2.5 Termination of Testing

The testing will be terminated upon the joint approval of GSFC's Technical Officer and the Westinghouse G/G Boom Program Director or their representatives. The decision will be based primarily upon the unit's operation and the amount of useful data acquired.

2.6 Test Data

Throughout the test program, data such as current readings of each deployer's field and armature, operational accumulative time, the unit's temperature and pressure, shall be recorded often enough to show the trend of the system's operation during the testing program. This data should be recorded in a concise and organized manner. All data and events should likewise be recorded in a standard form 2509E Test log book, or its equivalent, as a permanent record.

2.7 Test Report

Upon the completion of the "Special Prototype Testing" and the compilation of test data, a test report will be issued, and will become part of the Qualification Test Report of the Prototype Unit. This report will be generated by Westinghouse personnel.

3.0 TEST PROCEDURE

3.1 Thermocouple Locations

NOTE: Thermocouples #3 through #15 are located on the exterior of the unit. Nos. 3 through 12 are in the same positions as thermocouples, with equivalent numbers, indicated in Westinghouse document ATL0246, page 18, figure 2. Thermocouples number 13 and number 14 are number 1 and number 2 respectively of the figure 2 of ATL0246. Thermocouple No. 15 is on the center of the long side of the G/G Boom System.

TC#	LOCATION
1	Master Flex Spline
2	Slave Flex Spline
3	In Area of Scissoring Mechanism Box (see above note)
4	In Area of Scissoring Mechanism Box (see above note)
5	In Area of Scissoring Mechanism Box (see above note)
6	In Area of Master Boom Opening (see above note)
7	In Area of Slave Boom Opening (see above note)
8	On Short Side of Unit's Exterior (see above note)
9	On Top of Unit; Near Short Side (see above note)
10	On Top of Unit; Near Short Side (see above note)
11	On Top, Attached to the Exterior Stainless Steel Knob Connected to the Master Reel (see above note)
12	On Top, Attached to the Exterior Stainless Steel Knob Connected to the Slave Reel (see above note)
13	Underside of Unit, In Area of Scissoring Mechanism (see above note)
14	Underside of Unit, In Area of Scissoring Mechanism (see above note)
15	In Center of Long Side of the Unit (see above note)

3.2 Thermal-Vacuum Procedure

The G/G Boom System and its mounting fixture shall be installed securely in the GSFC/NASA Thermal-Vacuum Chamber in such a manner as to be thermally isolated from the mounting fixutre. The unit's installation should be in such a way that it will not be exposed to any abnormally hot or cold sources.

Thermocouples will be installed on the Unit as indicated in section 3.1 of this document (See figure 2 of Westinghouse Test Specification Number ATL0246). The average of these fifteen (15) thermocouples should be considered as the unit's temperature. However, if any problems should arise with thermally controlling the unit, thermocouples numbered one (1) and two (2) (master and slave flex splines of the drive system) shall take preference over all other thermocouples for the unit's temperature control.

Also the test set-up should give the test conductor the capability of running the deployers of the G/G Boom System independantly of the control circuit or of running the deployers with the control circuit. The changeover capability should be external to the chamber.

(NOTE: The wiring capability which makes this possible is indicated in Westinghouse ATL Drawing EVT-SK-B3541, Rev. B)

3.2.1 Test Sequence (See Figure No. 1 of this Document)

a. Installation of the Unit

With the unit installed securely in the chamber, and all thermocouples and electrical cables attached to the unit, secure the chamber.

b. Low Temperature with Vacuum

The G/G Boom System will first be exposed to a low temperature of $-22^{\circ}C \pm 2^{\circ}C$ ($-7.6^{\circ}F \pm 4^{\circ}F$) and a vacuum of less than 1.0×10^{-5} mmHG. When the unit's average temperature falls within the temperature and vacuum requirements, it will be functionally tested as indicated in section 5.0.

(NOTE: It may be necessary to "soak" the unit at the specified temperature and pressures, in order to insure that the functional testing be performed during "reasonable" working hours. This variable soak time requirement shall not invalidate the test results. These times should be recorded and become part of the test data.)

c. High Temperature with Vacuum

Upon the satisfactory completion of the functional testing at the cold case ($-22^{o}C$), the unit will be exposed to a $+60^{o}C \pm 2^{o}C$ ($139^{o}F \pm 4^{o}F$) and a pressure of less than 1.0×10^{-5} mmHG. Once these conditions have been achieved, it will then be functionally tested as indicated in section 5.0 of this document.

d. Cycling

If there are satisfactory results from the high temperature functional test the unit will remain at the high temperature ($60^{o}C \pm 2^{o}C$) and the boom will be extended and retracted for another 45 minutes in the same manner as described in section 5.0. At this time, if no problems have been encountered, the unit will be recycled through the cold and hot cases until the GSFC Technical Officer and the Westinghouse G/G Boom Program Director or their designated representatives terminate the testing program.

4.0 PHYSICAL INSPECTION

Before and after the environmental test a physical inspection will be performed. This will consist of a visual examination of the G/G Boom System and necessary component parts. The degree of disassembly required in the unit's inspection will be determined by the NASA/GSFC Technical Officer and the Westinghouse G/G Boom Program Director or their designated representatives. Any discrepancies noted should be properly recorded and indicated in the written test report.

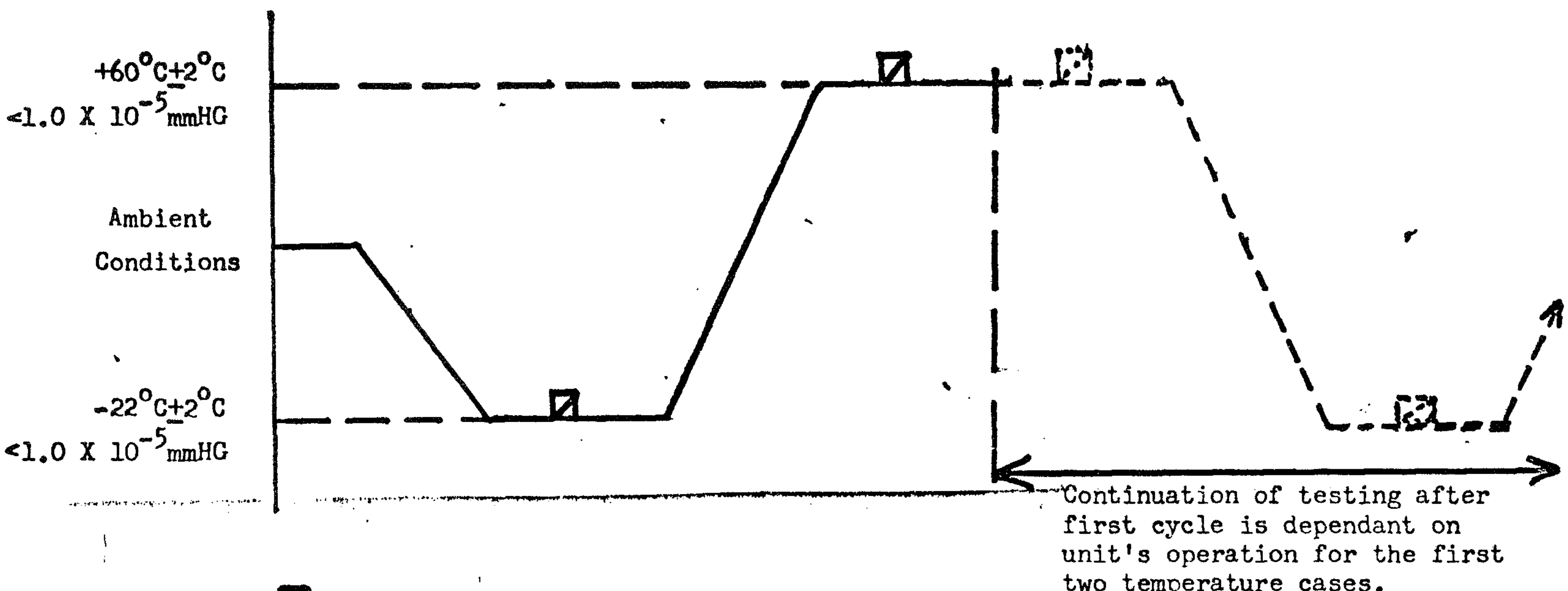
5.0 FUNCTIONAL TESTING

With the unit at the prescribed temperature and pressure, the deployers (master and slave) will be extended and retracted directly without the use of the control circuit and with an input voltage of 24 volts DC for an accumulative operational time of forty-five (45) minutes. During these extensions and retractions accumulative time, and current readings of each deployer's field and armature shall be recorded. These readings should be taken often enough to show the trend of the unit's operation during the testing program. If at anytime the NASA/GSFC Technical Officer directs Westinghouse to operate the boom system through the control circuit, this will be done to the specifications of the NASA/GSFC Technical Officer and data will be taken accordingly.

PROFILE FOR

GRAVITY-GRADIENT BOOM

SPECIAL PROTOTYPE TESTING



☒ Limited extension and retraction tests for an accumulative running time of 45 minutes.

FIGURE 1

SPECIAL HARMONIC DRIVE TEST REPORT

Objective: To operate two ATS boom deployers in a simulated environment for the purpose of demonstrating an acceptable operational life time (beyond one hour of operation in ambient environment) for the deployer harmonic drives in space.

Test set up: The half system housing containing the two deployers was suspended in an 8 foot thermal-vacuum chamber @ NASA (Goddard). The unit was electrically wired so that the deployers could be operated independently of the control circuit as well as thru the control circuit. Instrumentation was provided to monitor for each deployer, field and armature currents, input voltage, potentiometer voltages and the elapsed operating time. The unit was situated in the chamber such that 48 inches of deployment of each boom could be achieved. The half system was adequately instrumented with thermocouples and a digital read out of all temperatures was provided.

*Test procedure: The operating time on the deployer harmonic drives was achieved by alternately extending and retracting the booms $\approx$ 10 feet for 60 minutes of room ambient operation (at Westinghouse) and $\approx$ 4 feet for the remaining tests (@ NASA). Field and armature currents were logged for each retract cycle during the pre-thermal vacuum 60 minute ambient test and after every 2 minutes of operation (on nearest retract cycle) for the remaining testing. The number of cycles of normal operation required of the two harmonic drives during the test are given in Table I.

Table I

Environment	Slave	Master
Room Ambient	66	90
-7.6°F, 10^{-5} torr	180	180
+138°F, 10^{-5} torr	150	80
Total	396	350

The order in which testing was done is as follows:

(1) Prethermal-vacuum room ambient testing

**(2) -7.6°F vacuum test @ 10^{-5} torr

***(3) +138°F vacuum test @ 10^{-5} torr

(4) Postthermal-vacuum room ambient testing

(5) Room ambient temperature @ 10^{-5} torr

*** - After 20 minutes of operation, the retraction of the master boom became sluggish @ 24 volts. Consequently, the vacuum was released and the unit was disassembled. The master deployer harmonic drive was inspected and definite tooth wear was observed. The unit was then reassembled without disturbing the harmonic drive spline teeth in any way (loose debris was not removed) and the test was continued.

** - After 34 minutes of operation @ -7.6°F and 10^{-5} torr, the master boom broke in two due to excessive tab damage ($\simeq$200 cycles of boom deployment had occurred prior to this). The unit was removed from the chamber, the damaged boom was removed from each deployer and the test was resumed.

* - Detailed test procedure is presented in T853589.

<u>Test results</u>: The test results are shown in Table II. The results are expressed in terms of the elapsed operating time for each deployer in a specified environment.

The operating time is grouped into 2 categories; i.e. (1) normal and (2) abnormal. Normal operation implies that the deployer extended and retracted @ voltages equal to or less than 24 volts. Abnormal operation means that the deployer was unable to retract at 24 volts or less. Abnormal operating time is the elapsed time between the end of normal operation (just before voltage had to be increased above 24 volts) and the time for which the boom could not be retracted @ 33 volts (stall). All operating times recorded are for the case in which the deployers were operated independently of the control circuit. In addition to the operating times, extension threshold voltages are recorded. The extension threshold voltage is the lowest voltage @ the end of normal operation and @ the end of abnormal operation (33 v retraction stall). Finally, the retracting threshold voltage with the deployers operating thru the control ckt has been recorded. This information is only recorded @ the end of the 60 minute room ambient test and @ the end of the cold temperature portion of the thermal vacuum test because the master deployer reached a stall condition before the other environmental tests could be completed. The extension threshold voltage for operation via the control circuit was omitted because it was less than the retraction threshold.

Conclusions: The results of this test program indicate that the harmonic drives used on the ATS boom deployers can reliably operate in environments more extreme than anticipated for ATS-E, for 70 minutes beyond the 60 minutes room ambient testing required of all flight units. Furthermore, if voltage isn't a restriction (i.e., if the voltage available is as high as 33 v DC) an additional 15.1 minutes of operation can be counted on. As can be seen in Table II these figures refer to the master deployer harmonic drive. The slave deployer h.d. is even more impressive in that it logged 95 minutes beyond the 60 minutes room ambient operation @ voltages less than 24 VDC and an additional operating time of 25.8 minutes for voltages up to 33 volts. It should be noted that when the master deployer harmonic drive would not retract @ 33 volts (138°F and 10^{-5} torr) the unit would deploy @ 26 volts. Also, when the temperature was reduced to room ambient (70°F) the master extended @ 22 volts. Thus there is a direct indication that the primary mission of the ATS-E system; i.e. to extend the booms to their limit switches, could be accomplished after a minimum of 85 minutes of operation in a space environment.

This harmonic drive test had been more severe, in three specific ways, than the expected operation in space. To begin with, the maximum tooth load on the h.d. spline teeth (max. load occurs in the retract mode when the storage reel is fullest) is 20% higher than the maximum tooth load in space operation. This is because, in space, the tape storage reel in the retract mode never has more than 55 feet of boom stored on it (70 feet of boom still extended) whereas each deployer contained 90 feet of boom in the retract mode during this test. The increased diameter of the storage reel creates the increased tooth load. Likewise, the average spline tooth load in retraction encountered during the test was 45% higher than the average retraction tooth loading expected during an inversion maneuver in space. Next, the temperatures used during the test are more extreme than those anticipated in actual space operation. Finally, the multiple cycle operation required in a small thermal vacuum chamber to achieve the total operating time is hard on the harmonic drive spline teeth. The 350 cycles of operation logged on the master harmonic drive during normal operation (See Table I) meant that the unit started and stopped 700 times. The additional tooth loading occuring during each start-up transient (particularly impact loading due to the load suddenly being applied after the mechanism backlash has been removed) would occur no more often than 50 times for a typical flight unit harmonic drive.

Because of the additional severity of operation arising from the above three deviations from normal space operation, it can be concluded that the demonstrated normal operational life (70 minutes in space beyond 60 minutes in room ambient) is a conservative estimate of the available running time for the flight units in space.

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TABLE II

Environment	SLAVE				MASTER				Control Circuit Threshold Voltage In Retraction (Volt)
	Operating Time		Extension Threshold Voltage		Operating Time		Extension Threshold Voltage		
	Normal (Min)	Abnormal (Min)	Normal (Volt)	Abnormal (Volt)	Normal (Min)	Abnormal (Min)	Normal (Volt)	Abnormal (Volt)	
Room * Ambient Temp & Press	60	—	15.5	—	60	—	15	—	18
-7.6°F Temp 10^{-5} Torr Press	50	—	16	—	50	—	16	—	22
+138°F Temp 10^{-5} Torr Press	45	11.8	18	26	20	12.6	18	26	—
Room Ambient Temp & Press	—	13	—	17	—	13	—	17	—
Room Ambient Temp 10^{-5} Torr Press	—	14	—	18	—	2.5	—	22	—